THE PLANT DISEASE REPORTER

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PLANT DISEASE EPIDEMICS
and
IDENTIFICATION SECTION

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PLANT DISEASE EPIDEMICS AND IDENTIFICATION SECTION

Horticultural Crops Research Branch Plant Industry Station, Beltsville, Maryland
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IN THIS ISSUE

Antibiotics (See also WALLEN and BELL below): PETER A. ARK and STANLEY M. ALCORN discuss already proved and probable future contributions of antibiotics to plant disease control, page 85. R. N. GOODMAN and P. SHEPARD obtained promising results from tests with streptomycin preparations against peach bacterial spot, page 93. Of materials tested by HOUSTON B. COUCH and HERBERT COLE, Jr., for control of Merion bluegrass rust cycloheximide was most effective but was phytotoxic, page 103. Antibiotics were included among materials tested by R. H. PORTER for control of barley loose smut, page 106, and stripe and covered smut of barley, page 112. J. J. NATTI et al. discuss reasons for the increased prevalence of downy mildew on broccoli in New York, and report results of control tests, page 118. HARRY C. FINK et al. report results of 1955 potato seed piece treatments in Pennsylvania, page 125.

Maneb was superior to other fungicides tested for control of potato late blight in Prince Edward Island, reported by L. C. CALLBECK, page 126.

V. R. WALLEN and W. BELL summarize 1955 trials on treatment of vegetable seed for improved emergence, page 129.

A. E. THOMPSON and P. R. HEPLER report that most species of Asparagus inoculated with rust have shown some degree of susceptibility, page 133.

R. W. LEUKEL et al. summarize results of the 1955 sorghum seed-treatment tests, page 138.

Rhizopus oryzae is reported by R. H. PORTER as the cause of severe injury to sorghum seed, page 141.

Virus diseases: Barley stripe mosaic is common in the most important barley variety in Montana, according to a survey reported by M. M. AFANASIEV, page 142. Effect on citrus budwood certification programs of the possibility of transmission of the xyloporosis virus through seed of sweet lime is stressed by J. F. L. CHILDS, page 143.

Nematodes: A. J. GOHEEN and J. B. SMITH report evidence that the meadow nematode is a primary parasite of strawberry and a major factor in black root rot, page 146. The stunt nematode did not increase severity of bacterial wilt of tobacco in experiments reported by G. B. LUCAS and L. R. KRUSBERG, page 150.

The Committee on Cotton Disease Losses sends the 1955 estimates, page 153.

Pecan scab is reported from Mississippi on Stuart, up to now considered the most resistant variety, according to JOHN R. COLE and A. C. GOSSARD, page 156.

ROSS W. DAVIDSON and THOMAS E. HINDS report occurrence of the Hypoxylon canker of aspen in Colorado, page 157.

PHILIP J. LEYENDECKER and ROY M. NAKAYAMA summarize incidence of plant diseases in New Mexico in 1955, page 159.

Estimates of losses from plant diseases in Tennessee in 1955 are listed by J. O. ANDES, page 162.

Correction, page 164.

Annual increment of the meeting of the Potomac Division of the American Phytopathological Society, page 164.

December weather, page 165.

Preparation of manuscripts for the Plant Disease Reporter, page 166.

Vol. 40, No. 2--PLANT DISEASE REPORTER--Feb. 15, 1956

ANTIBIOTICS AS BACTERICIDES AND FUNGICIDES AGAINST DISEASES OF PLANTS

Peter A. Ark and Stanely M. Alcorn

Introduction

Although there are many chemical compounds in current use to prevent or eradicate diseases of plants, the attention of plant pathologists is now turning to a very special group of chemical compounds designated as antibiotics. Among the reasons for this trend is the hope of discovering a compound that will exhibit a minimum toxicity to plants, maximum toxicity against parasites, and the property of penetrating into plant cells and accumulating there in amounts detrimental to the parasite (3). The toxicity of many antibiotics to parasitic forms of life in very minute quantities is of considerable interest to plant pathologists for reasons both physiological and economical. The possibility of systemic or internal antibiotic action within the host plant is probably the most compelling reason why research along the lines of agricultural antibiotics is going forward full speed world-wide in laboratories dealing with plant life.

Antibiotics as Bactericides

Although penicillin is the oldest known antibiotic against bacterial diseases of both men and animals, streptomycin is the first antibiotic to function as a reliable remedy against many bacterial diseases of plants. Streptomycin is active against both gram-positive and gram-negative types of bacteria causing diseases of plants (5, 10). Plant diseases due to gram-positive bacteria are not numerous and for the most part are seed-borne. Seed treatment with streptomycin, 100 ppm or higher, is quite effective and can be recommended against such diseases as tomato canker, alfalfa wilt, and Stewart's disease of corn.

Many diseases of plants due to bacteria of the gram-negative group are quite destructive and cause, sometimes, the discontinuance of certain crops in certain regions. A good example of such a disease is fireblight of pear (Erwinia amylovora). In large scale experiments of the last 3 years, a high degree of success has attended the use of streptomycin against this disease. Control is brought about by applying streptomycin to the parts of the plant where most infection takes place, namely, the blossoms, and more precisely the nectaries of pear or apple flowers. The cycle of the disease is shown in Figure 1. The result of lack of control leads to serious damage to trees, as shown in Figure 2. Besides causing serious loss to the current crop, the disease, when finally checked by expensive cutting operations, reduces bearing wood and production for 5 or even 10 years. This, of course, leads to serious economic losses.

In California, as well as in other States, fireblight can be controlled quite successfully with copper sprays or dusts applied in full bloom. However, these materials, under certain climatic conditions, may cause severe russeting of the fruit. Streptomycin proved to be comparable with copper formulations in controlling fireblight, and can be safely used in any pear growing district. This can be seen from Table 1. In terms of the percentage of control of the disease, there seems to be no difference between formulations containing streptomycin singly or in combination with other antibiotics such as Terramycin, as in Agrimycin. The percentage of the control with streptomycin (wettable) alone was 71, 70, and 56 for 100, 50, and 25 ppm, respectively, as compared to 83, 63, and 35 percent respectively for the same concentrations of streptomycin plus Terramycin. Dunegan's 1954 data (8) on streptomycin-Terramycin sprays, obtained in California, seem to indicate that quite satisfactory control of fireblight can be attained by several weekly applications of streptomycin, 30 ppm, plus Terramycin, 3 ppm. However, our extensive observations in California on levels of streptomycin below 50 ppm reveal certain risks in adopting this schedule.

In California, streptomycin dust formulations have been experimented with for the last 3 years.

During the first 2 years a Wyoming 200-mesh bentonite was used as a carrier, and the results obtained were exceedingly variable. In 1955, pyrophyllite ABB or pyrophyllite Nuclay were used instead of bentonite as carriers, and proved superior because they release the streptomycin much more readily than does the bentonite. Laboratory tests showed that while no streptomycin in bioassayable quantities could be eluted from the bentonite-streptomycin dust, with distilled water of neutral reaction, large quantities were freely liberated by pyrophyllite-streptomycin dusts. It must be mentioned that the pH of the pyrophyllite ABB dust was 4.5 for one lot and 6.5 for another lot, and for the pyrophyllite Nuclay dust 8.95. The pyrophyllite

Table 1. Control of fireblight of pear (Erwinia amylovora) with a) streptomycin; b) streptomycin-Terramycin sprays and c) copper-lime dust.

Treatment	No. trees sprayed	Average number cuts of blight per tree
Streptomycin (ppm)		
100	93	0.602
50	93	0.645
25	93	0.924
Copper-Lime Dust	363	0.688
Check (no treatment)	122	2.090
Streptomycin-Terramycin (ppm)		
100	400	0.75
50	400	1.61
25	694	2.83
10	473	6.44
Check (no treatment)	150	4.37

Table 2. Experimental control of walnut blight with copper and streptomycin (dust and wettable) at Linden orchards, Linden, California, summer 1955. Treatments were made at early pre-bloom, middle of bloom (40-50% open blossoms), and post-bloom periods.

Plot	Treatment	No. of trees	Disease percent	Percent disease in relation to check	Percentage of control
1	No treatment -- Check	150	24.6	100	0
2	10% Copper A dust	42	11.6	47	53
3	Streptomycin-Pyrophyllite dust, 500 ppm	42	5.9	24	76
4	Streptomycin-Pyrophyllite dust, 1000 ppm	42	7.6	32	68
5	Streptomycin, Wettable, 50 ppm	56	2.7	11	89

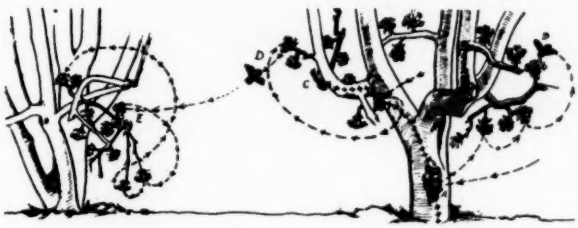

FIGURE 1. Common modes of dissemination of fireblight. The bacteria are first carried from holdover cankers (A) to the blossoms by flies (B), ants (C), etc. Then blossom-visiting insects, including bees (D), flies, and many others, carry the organism to other blossoms such as those at E.

FIGURE 2. Disastrous results of fireblight in Bartlett pear orchard. This occurs when no control measures are undertaken.

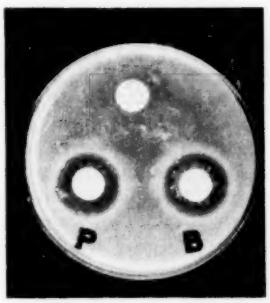

FIGURE 3. Release of streptomycin from streptomycin-pyrophyllite dust (P) and streptomycin-bentonite dust to which K_2HPO_4 was added (B). The disc showing no inhibition zone around it was dipped in the streptomycin-bentonite eluate without K_2HPO_4.

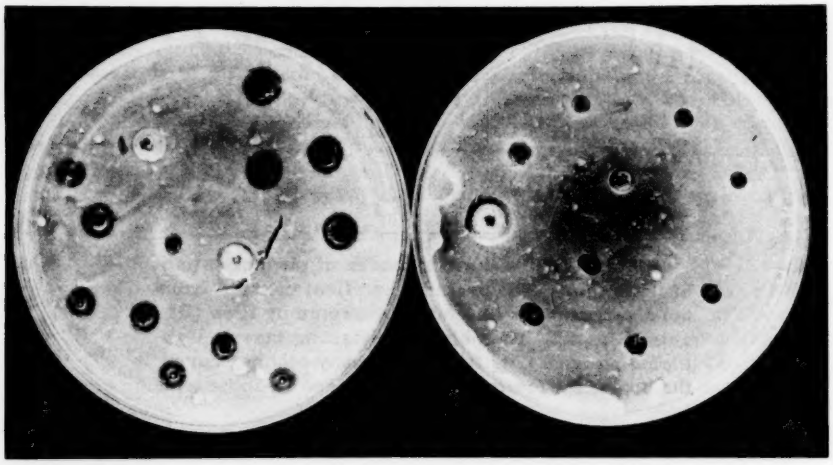

FIGURE 4. Streptomycin liberated into medium by pieces of pear fruit from a tree (Winter Nelis) treated with 1.1 g. of streptomycin into bored holes around the tree. Treatment made March 22, 1954; pear fruit tested March 30, 1955.

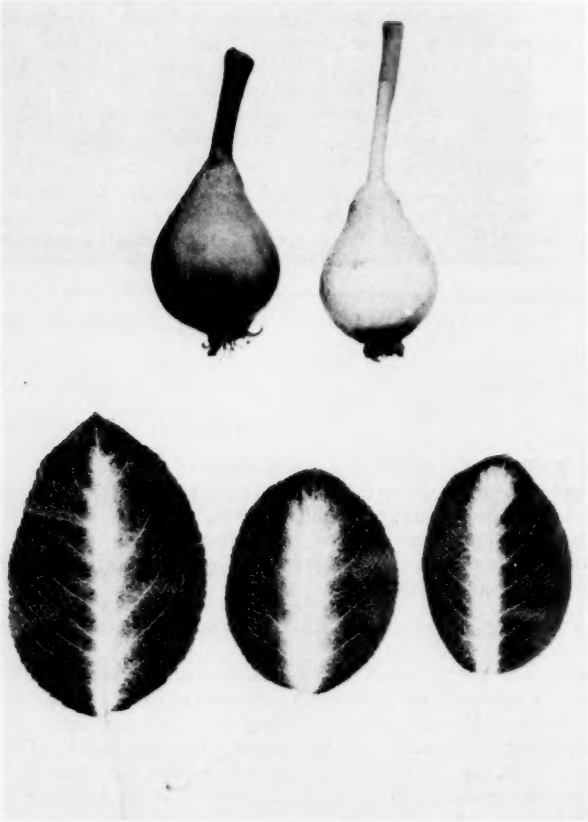

FIGURE 5. Leaf and fruit chlorosis on Winter Nelis pear tree injected in the preceding season with 1.1 g. streptomycin base. Fruit on left is a check.

dusts when tested for bioactivity 3 months after formulation still had the same bioactivity as at the beginning. This marked difference between bentonite and pyrophyllite streptomycin formulations was displayed in the field. Thus in one pear orchard in which pyrophyllite and bentonite streptomycin dusts were applied every 5 days during the blossoming period, good control of blight was obtained with the pyrophyllite-streptomycin formulation, while fireblight developed in epidemic proportions in the acreage dusted with the bentonite-streptomycin formulation. Copper dust in the same orchard gave slightly less control of the blight than the pyrophyllite-streptomycin.

Pyrophyllite-streptomycin dusts, 500 and 1,000 ppm, compared well with wettable streptomycin, 50 ppm, in controlling walnut blight caused by Xanthomonas juglandis, and were somewhat better than a 10% copper A dust (Table 2).

It appears that when streptomycin is formulated with bentonite clay, there results such a strong physical union that streptomycin is not detached from the bentonite particle in quantities enough to be useful at the locus of application. However, by a very simple procedure of adding dipotassium phosphate, peptone, or certain other substances, it is possible to liberate the streptomycin and render it available for action. Under these conditions, enough streptomycin can be released from a bentonite-streptomycin complex to be useful as a bactericide. Figure 3 leaves no doubt about the liberation of streptomycin under such circumstances.

That the pH of the dust carrier does not seem to play a decisive role is shown by formulating streptomycin with Vermiculite dust, the pH of which is 9.1. Thus streptomycin-treated Vermiculite does not liberate any detectable streptomycin on being eluted in distilled water, but the addition of 1% or less of dipotassium phosphate results in a prompt release of large quantities of the antibiotic. The same phenomenon was demonstrated in Vermiculite saturated with different strengths of streptomycin solution, placed in pots and assayed 17 and 21 days later. Talc, however, does not behave like the materials discussed above. No streptomycin could be liberated from talc either by distilled water alone or by treating with K_2HPO_4.

To demonstrate the actual performance of pyrophyllite-streptomycin dusts on plants, both greenhouse and field experiments were carried out in which pear, tomato, sugar beet, and pinto bean leaves were dusted with the pyrophyllite-streptomycin dusts containing 500 and 1,000 ppm streptomycin base, with bentonite-streptomycin plus 1% K_2HPO_4, and with bentonite-streptomycin alone. Prior to dusting, the experimental plants were held in a humidity chamber at 80 percent relative humidity and 75° F. After dusting, the plants were held for 24 hours at 75° but with the relative humidity fluctuating between 40 and 75 percent. Then the dusted leaves were washed thoroughly with tap water, blotted between sheets of filter paper, and bioassayed by cutting out 12mm discs and placing them on agar plates seeded with the test organism. The same procedure was followed for the bentonite-streptomycin formulation and all corresponding checks. Bioassay revealed demonstrable quantities of streptomycin from the pyrophyllite-streptomycin and the bentonite-streptomycin plus 1% K_2HPO_4, and none from the checks. This clearly indicated the ability of properly prepared streptomycin dusts to release adequate quantities of the antibiotic.

That there was plenty of freely available streptomycin in pear blossoms receiving the pyrophyllite-streptomycin dust was shown by bioassay tests on dusted pear blossoms, sampled every 24 hours for 3 consecutive days. The treated blossoms were collected in the field in polyethylene bags, washed well to dislocate dust particles, and tested directly as tissue blocks, or by means of paper discs saturated in the juice of the pressed receptacles, placed on agar plates inoculated with the test organism. The evidence that streptomycin was available from this new formulation of the antibiotic is corroborated by the control of fireblight obtained in orchard test plots.

Recent work by Gray (9) on increasing the effectiveness of streptomycin against bacterial blight of beans by adding glycerin indicates how we may further improve the quality of antibiotic dusts for plant disease control. It seems that the longer the exposure of plant surfaces to streptomycin in a wet form, the better the protection obtained against bacterial agents. Glycerin being a humectant may retard the drying of the spray film.

It had been reported by many workers that slight to severe chlorosis occurs in plants treated with 50 ppm or higher concentrations of streptomycin. Chlorosis usually persists all season but does not reappear in the following season. In our study of the movement of streptomycin in large pear trees, a very interesting observation was made. On March 12, 1954, 1.1 g. of streptomycin sulfate was injected, in 11 capsules, in holes bored around the trunk of a 20-year old Winter Nelis pear tree. No symptoms of any kind were noticed in the tree during the 1954 growing season. At the end of March 1955, the tree showed all the typical signs of streptomycin chlorosis on the newly developed leaves and shoots (Fig. 5). The shoots assumed a very

peculiar deep pink color and the terminal leaves and flower buds were strongly chlorotic, almost white. The fruit that developed on these shoots was creamy white. The leaves and the fruit when bioassayed contained a large amount of streptomycin. Streptomycin activity liberated by cut pieces of such fruit is shown in Figure 4. The shoots continued to be pink throughout the growing season and the leaves on those shoots remained strongly chlorotic. However, not all the shoots on the tree developed these extreme signs of streptomycin toxicity. These observations strongly suggest movement of streptomycin upward from artificially made wounds, and its accumulation in certain areas of the plant. This latter feature is, of course, in agreement with Pramer's observations (14, 15) of the accumulation of streptomycin in the upper part of a plant, and also demonstrates a remarkable stability of streptomycin within plants. This pattern of behavior may be of significance from the standpoint of the agencies concerned with regulation of the use of plant poisons in relation to human welfare. It must be noted that no chlorosis or signs of poisoning were apparent when the concentration of the streptomycin as dust was raised to 2,000 ppm, and as much as 60 pounds of the dust was used per acre of 120 pear trees.

The bactericidal action of streptomycin does not seem to be displayed equally with different bacterial diseases. Thus, while streptomycin was found to give excellent control of wildfire (Pseudomonas tabaci) in tobacco plant beds at rates of 200 and 400 ppm, control of bacterial leaf spot of peppers and tomatoes, caused by Xanthomonas vesicatoria, is variable. A similar situation exists in the common bacterial blight of bean (X. phaseoli). Crossan (7) in his recent report on the use of streptomycin on pepper plants for the control of X. vesicatoria came to the conclusion that there seems to be a preferential absorption of streptomycin by the leaves of pepper and snap-bean plants, that streptomycin does not eradicate the causal organism of bacterial leaf spot of pepper from established leaf lesions when used at concentrations as high as 500 ppm, and that its action is that of a bacteriostatic protectant when used at concentrations of 250 ppm. A situation like this is a challenge to both plant pathologists and plant physiologists in dealing with the relation of plant cuticle to the access of chemicals to plant cells.

It is also of interest to note that in some cases combining streptomycin with other chemicals gives a much improved control of certain plant diseases. Thus Cox (6) reports much better control of bacterial blight of celery (Pseudomonas apii) with the addition of copper A compound to 300 ppm streptomycin than with the streptomycin or copper alone.

The antibiotic aureomycin has been found useful in controlling black rot of swede (Xanthomonas campestris) by Sutton and Bell (17). The treatment consisted in dipping the seed in a 1,000 ppm solution for 30 minutes and drying the seed for 3 days before planting. It also has been demonstrated that aureomycin is compatible with such fungicides as Arasan and Spergon, which are standard seed treatments against numerous seed-borne fungi. In our experience, spraying pear and walnut trees with aureomycin 50 ppm for fireblight and walnut blight was not successful. Above this concentration aureomycin was injurious to the leaves when tried under greenhouse conditions, and for this reason was not tried in the field. Other antibiotics such as neomycin, Terramycin, polymyxin, and tetracycline, although showing a very high degree of activity against numerous plant pathogenic bacteria in vitro, so far have proved of no practical value in vivo when tried against such pathogens as Erwinia amylovora, Xanthomonas juglandis, Pseudomonas syringae, and P. caryophylli.

Antibiotics as Fungicides

Soon after the discovery of streptomycin, an antibiotic was isolated from certain strains of Streptomyces griseus which was named Acti-dione (19) and which showed remarkable fungicidal properties against a great number of fungi pathogenic both for men and plants. This discovery led to a search for more antibiotics possessing fungicidal properties. As a result, a large number of antibiotics with fungicidal properties has been described. However, their actual application in the field of plant pathology has not met with the same degree of success as has streptomycin. Some of the reasons are a high degree of plant toxicity, limited spectrum of antifungal activity, poor adherence to plant and fungus surfaces, and instability in solution. Following the discovery of griseofulvin by Brian plant pathologists are trying to find materials which will promote systemicity of the griseofulvin and potency of the Acti-dione.

Griseofulvin, an antifungal compound produced by Penicillium nigricans, is quite stable in aqueous solutions, readily goes into the plant through the root system, permeates the plant, and exerts strong fungistatic action. Preliminary experiments demonstrate its ability to check certain fungus diseases of plants by its internal systemic action (4). It is not phytotoxic.

Acti-dione is a product of certain strains of Streptomyces griseus and chemically is cycloheximide. It is strongly fungicidal but at the same time highly lethal to plants. It has been tried

against powdery mildews on beans, roses, and other plants. In certain low concentrations it affords good protection against mildews, but its phytotoxicity outweighs its usefulness for many species of plants. It is recommended for controlling the fungus leaf spot of cherries caused by Coccomyces hiemalis, but its application is safe only in the fall of the year when some injury to the leaves may be tolerated without ill effects on the whole tree. Recently, Ogawa (13) found it effective against grape powdery mildew (Uncinula necator) and brown rot (Monilinia fructicola) of peaches, but again the injury factor may limit its use for those diseases.

Wallen (18) recently reported that spray applications of Acti-dione at concentrations from 25 to 500 ppm gave perfect control of stem rust (Puccinia graminis) of wheat. At concentrations of 50 to 500 ppm, symptoms of phytotoxicity in the form of leaf injury appeared, but the plants appeared to recover in most cases. He adds that yields of sprayed plots were consistently greater than those of unsprayed control plots.

There are apparently excellent fungicidal antibiotics such as antimycin and helixin, but their availability for a more extensive evaluation seems to be delayed because of some technical difficulties. Antimycin is reported to be very effective against such important pathogens as Venturia inaequalis, and helixin is effective against a large number of seed-borne diseases of cereals (11, 12). Lately, there have appeared a series of antibiotics which show a considerable degree of activity against fungus pathogens of men and which are available for evaluation on fungi causing diseases of plants.

Of these recent antibiotics, we selected candicidin as the most promising fungicidal antibiotic to study in relation to a number of important fungus diseases of plants. Preliminary reports on candicidin are presented in the two papers in 1954 and 1955 (1, 2).

It must be pointed out that, in 1954, Silverman and Hart (16) reported no control of wheat stem rust by candicidin on plants inoculated by rubbing. In 1955, Wallen also presented evidence that the candicidin he used did not give any control of the stem rust of wheat (strain 15B) even in concentrations as high as 500 ppm when he sprayed 10 ml. of the antibiotic solution on wheat plants 4 inches high in pots. Spraying was done with a de Vilbiss #251 atomizer and inoculation was performed by rubbing the leaves with the thumb and forefinger contaminated with the uredospores. It appears from these tests that the workers had in mind systemic action of the antibiotic rather than surface protection. It is apparent that when one is dealing with a strictly surface protectant, inoculation should be by some method other than rubbing.

For this reason, in our tests with wheat rust we used the talc dust procedure which consisted in combining the spores with talc in a ratio of approximately 1:50 and insufflating the mixture onto wheat plants after atomizing the plants with the antibiotic. Although the method needs further improvement, we feel that this inoculation technique affords a satisfactory method for ascertaining the effectiveness of candicidin and other materials against the grass rusts. In our greenhouse experiments there was a consistent and significant reduction of the wheat rust on plants treated with candicidin A (Merck & Co.). In typical experiments there was complete control of the wheat rust with candicidin, 1:5,000, immediately before inoculation, and 81 to 85 percent control in lots sprayed 7 days before inoculation.

Candicidin has been found effective against the uredial stage of Cronartium ribicola, giving 98.2 and 93.1 percent control at the rate of 1:5,000, sprayed 2 and 24 hours before inoculation respectively, while Dithane Z78 under similar conditions showed 90.6 and 90.7 percent control. The candicidin did not compare well with Dithane Z78 when used against carnation rust, Uromyces caryophyllini, but was fairly effective against snapdragon rust, Puccinia antirrhini, giving 95 percent control when sprayed with candicidin 200 ppm immediately before inoculation and 87 percent 14 days after spraying. Perfect control of bean rust, Uromyces phaseoli, is obtainable at concentrations of candicidin of 1:5,000 and 1:16>666.

One of the most serious problems encountered in our investigations in connection with the research on the protective action of candicidin was the matter of proper wetting of the leaf surfaces of the treated plants. It is felt that this is one of the principal reasons for the differences in results between the candicidin and the Dithane Z78. The latter is in such a formulation that it wets most of the leaf surfaces quite effectively. Even when the candicidin was incorporated in 1% dimethyl formamide plus a spreader, wetting was not perfect.

In the field the candicidin, 1:5,000, was tested on Poa pratensis against stem rust, in cooperation with Drs. Houston and Sonders of the University of California at Davis, California. Results indicated consistently less rust in plots sprayed twice with candicidin.

Protective tests against brown rot, Monilinia fructicola, on Prunus seedlings indicated that the candicidin was as effective as captan, a standard fungicide, and was not injurious to foliage. In our earlier report (2) we showed that peach fruits dipped for 1/2 hour in 1:16>666 candicidin and stored at 32° F for 3 and 21 days before inoculation developed 0 and 16 percent brown rot

respectively, as compared with 22 percent for 1:33>333 candicidin and 66 percent and 100 percent for the 1:5,000 captan-treated fruits. This favorable action of the candicidin may have some practical importance in solving problems of spoilage in storage or transit.

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INDICATIONS OF XANTHOMONAS PRUNI CONTROL WITH ANTIBIOTIC SPRAYS[1]

R. N. Goodman[2] and P. Shepard[3]

Several species of the genus Prunus are susceptible to a bacterial disease commonly known as "bacterial spot" or "bacterial shot-hole". The causal organism, first described by Erwin F. Smith, has been referred to in the literature as Pseudomonas pruni, Bacterium pruni, Phytomonas pruni, and finally as Xanthomonas pruni.

The specific Prunus species most seriously affected are Prunus salicina (Japanese plum), Prunus persica (peach), Prunus armeniaca (apricot) and Prunus persica var. nectarina (nectarine).

From a standpoint of economic importance, X. pruni has precluded the commercial production of Japanese plum in many regions of the country. In addition a number of excellent peach varieties are no longer grown commercially due to their extreme susceptibility to this disease. The leading commercial peach variety, Elberta, is moderately susceptible and in years favorable for the development of "bacterial shot-hole", economic losses may be appreciable. Dunegan (1) has stated that injury to peach fruit may be as high as 100 percent in weak trees whereas the average tree in good vigor will, under similar circumstances, demonstrate fruit injury of 33 to 76 percent. In some peach breeding programs resistance of a new variety to X. pruni is one of the salient criteria for acceptability.

Economic losses sustained as a result of X. pruni are four-fold: (a) damage to fruit resulting from direct infection, (b) impairment of leaf function by spotting injury, (c) devitalization of the tree through premature defoliation and (d) occurrence of stem cankers, particularly on Japanese plums, which cause dieback of twigs and branches.

Since detailed investigations relating the etiology, morphology and cultural characteristics have been reported elsewhere by Rolfs (3) and Dunegan (1), these factors will not be discussed in this report. Attention is called however, to the work of Dunegan wherein the first conclusive evidence regarding the overwintering habit and dissemination of X. pruni inoculum is presented. This study established the stem canker as the source of inoculum for primary infection of foliage and fruit and demonstrated the importance of precipitation in spreading inoculum from the canker sites. It was on the basis of this information that the spray schedule in the current study was formulated.

For the past three years streptomycin and streptomycin-Terramycin sprays have been applied in our peach orchards for X. pruni control, with slight indications of positive results. However, extremely dry conditions during the 1952, 1953, and 1954 growing seasons were not conducive for appreciable symptom expression. In 1955, spring rains and frequent summer showers presented conditions which proved more favorable for the development of "bacterial shot hole".

Experimental

A peach variety block at the Missouri State Fruit Experiment Station at Mountain Grove was selected as a site to conduct the 1955 spray trials. Four varieties known to vary considerably in their susceptibility to X. pruni, July Elberta (often called Burbank July Elberta), Elberta, Flaming Gold, and Hale Haven, were treated.

Each variety consisted of a single tree-row of 24 trees. The individual rows were subdivided into three 8-tree plots wherein the first plot was a check, the second received Agrimycin at 100 ppm and the third Agrimycin at 50 ppm.

All antibiotic-treated trees were sprayed 5 times and following the fifth application the antibiotic spray plots were further subdivided so that one-half (4 trees) received an additional 2 sprays. There were, therefore, trees that had 5 sprays and others that had 7. The design of the spray block appears in Figure 1.

Unfortunately, two severe frosts occurred prior to and during bloom and as a result no fruit were set. However, the experiment was conducted as planned since it was believed that

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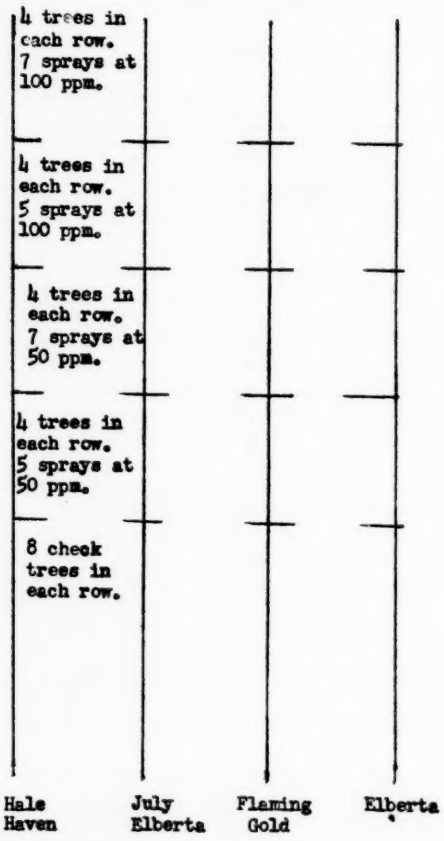
4 trees in each row. 7 sprays at 100 ppm.
4 trees in each row. 5 sprays at 100 ppm.
4 trees in each row. 7 sprays at 50 ppm.
4 trees in each row. 5 sprays at 50 ppm.
8 check trees in each row.
Hale Haven
July Elberta
Flaming Gold
Elberta

FIGURE 1.
Spray plot design Mountain Grove, Missouri, 1955.

leaf spotting and leaf defoliation could be used as indices of infection.

The spray schedule was initiated on April 28 or approximately 4 weeks after bloom. Subsequent sprays were applied following each extended period of precipitation provided that at least 7 days had elapsed since the preceding application. Thus, if an extended rainy period occurred, for example, two days after a spray treatment a full 7-day interval was allowed to elapse before the next spray was put on. The spray schedule, approximate bloom and harvest dates appear in Table 1.

Initial data noting the effectiveness of the sprays were recorded on July 11 and 12. The incidence of infection was determined in the following manner:

1. Four trees from each 8-tree treated and control plot were selected, on the basis of uniformity of size and vigor, from which the incidence of disease was to be determined.
2. Four shoots, 12-18 inches in length, were collected from each of the four sides, center and top of each tree (a total of 24 shoots per tree).
3. Each shoot was closely inspected and the four most heavily infected leaves from each shoot were removed and the number of spots on each leaf was counted and recorded. However, since leaf abscission as well as leaf spotting is induced by X. pruni both factors were considered

Table 1. Dates of bloom, spray applications and approximate time of harvest.

Average date of full bloom for the 4 varieties, April 1-5		
First spray application -- (Agrimycin A-200)*	April	28
Second spray application -- (Agrimycin A-200)	May	12
Third spray application -- (Agrimycin A-200)	May	19
Fourth spray application -- (Agrimycin A-200)	May	31
Fifth spray application -- (Agrimycin 100)**	June	15
Sixth spray application -- (Agrimycin 100)	July	9
Seventh spray application -- (Agrimycin 100)	July	21
Hale Haven harvest --	August	4
July Elberta harvest --	August	7
Flaming Gold Harvest --	August	17
Elberta harvest --	August	20

* Agrimycin A-200 = A trademarked formulation of Charles Pfizer which is a liquid concentrate of streptomycin (35%).
** Agrimycin 100=A trademarked formulation of Charles Pfizer which is in powdered form and contains 15% streptomycin and 1.5% oxytetracycline.

in determining the incidences of infection.

4. Number of lesions and leaf abscission were rated as follows: 1-5 spots = 1, 6-15 = 2, 16-25 = 3, 26-35 = 4, over 35 or abscissed leaf = 5. Thus if a shoot had 2 leaves with over 35 lesions and 2 leaves missing it received the heaviest rating of 5, 5, 5, 5.
5. It was recognized that other factors such as wind, hail and insect damage might be responsible for some leaf abscission; however, these would have affected all trees and treatments more or less similarly.

On August 22 and 23 the spray plots were again examined and at this time, which was after the normal harvest date for all varieties, the incidence of disease was interpreted by the amount of leaf abscission that had occurred. Shoots were collected exactly as indicated for the initial examination. Although many shoots, particularly in the control trees, were completely defoliated, only 4 leaf positions were counted. Therefore if a shoot had one leaf missing it was scored as 1, 2 missing = 2, 3 missing = 3, and 4 or more missing = 4.

Results

On July 8 the plots were given a cursory examination to evaluate the effectiveness of the spray program and it was evident that considerable reduction of infection had been effected. It was at this time that the decision was made to apply additional sprays to one half of the treated trees, the intent here being to determine whether or not the degree of control observed could be maintained through the normal harvest period by extending the spray schedule.

It was apparent that the number of leaf lesions on the treated trees was considerably less than on the controls; however, of even greater significance was the difference in type of lesion noted between leaves from treated and untreated trees. X. pruni leaf-lesions on the control trees had blackened and coalesced into large necrotic areas, and the typical leaf tearing and shot-holing effects were in evidence. On the leaves from treated trees no necrotic lesions

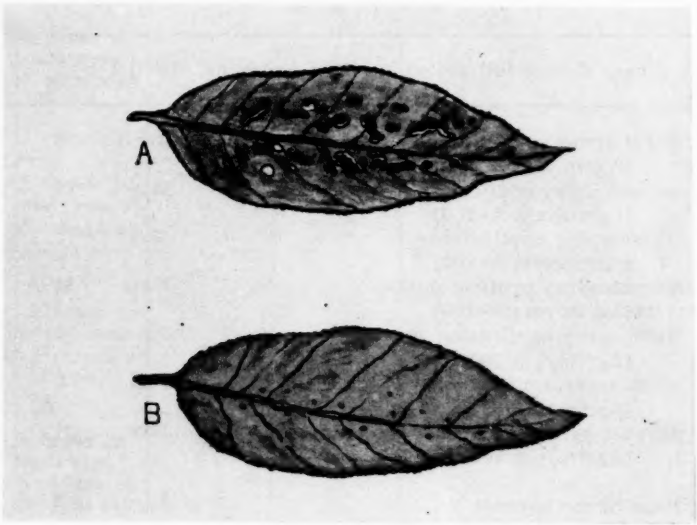

FIGURE 2. A -- Typical peach leaf from unsprayed controls tree. B -- Typical peach leaf from antibiotic-sprayed tree (5-sprays).

were observed, the lesions were faint and small and it was apparent that, for the most part, they were recent infections. Examining the precipitation records, it was conjectured that these infections might have occurred during the extended period of precipitation from June 20 through June 28. Rainfall was measurable on 6 days during this 9-day period and the total precipitation recorded was 2.37 inches. This infection period followed the fifth spray (June 15) by 5 days and the sixth spray was not applied until July 9. A comparison of the type of infection present on leaves from treated and control trees appears in Figure 2.

Actual data denoting the incidence of disease, through counts on number of lesions per leaf and leaf abscission, were initially recorded on July 11 and 12. These data appear in Tables 2-5 and are summarized below.

1. There were considerably fewer lesions on leaves from treated trees than on leaves from the controls.
2. The variation in severity of infection between the 100 and 50 ppm treatments does not appear to be significant.
3. From previous reports in the literature, July Elberta had been found to be the most susceptible to X. pruni of the four varieties studied. The others, in declining order of susceptibility were Elberta, Flaming Gold, and Hale Haven, with the latter being quite resistant. The amount of infection recorded for the controls is in complete agreement with these observations.

On August 22 and 23, observations were again made and the recorded data appear in Table 6. At this time the incidence of infection was measured by the extent of defoliation. These data are summarized below.

1. Antibiotic treated trees had suffered far less from defoliation than had the controls. By mid-August this variation was a striking one and could easily be discerned visually.
2. The ratio of defoliation between treated and controls was approximately 1-8.

Table 2. Effect of Agrimycin on peach bacterial spot, as indicated by leaf spotting and defoliation on treated and untreated trees. July Elberta variety, Mountain Grove, Missouri, 1955.

Treatment:	Counts[a] of leaf lesions and missing leaves on trees receiving indicated treatment											
	Control trees				Agrimycin							
					50 ppm				100 ppm			
Tree no.	1	2	3	4	1	2	3	4	1	2	3	4
Shoot no. 1	3222[b]	5544	4443	5555	3322	2223	2111	5221	2222	5332	3222	2221
2	5543	5555	5553	5555	2222	2221	1111	2222	2221	3333	2211	2222
3	5332	5555	5443	5555	2222	5522	**1111**	**2212**	2222	2222	**2222**	2222
4	4433	5444	5533	5544	2222	2221	2111	5111	5444	2222	3222	5222
5	5555	5322	4433	4422	3334	3332	5222	2211	2222	5222	5222	2211
6	3222	5422	4333	4443	2222	3222	**2211**	5221	5532	5333	2222	2222
7	5432	5555	5322	5555	2221	2222	2222	5531	2222	3322	2222	5222
8	2222	5544	5553	5554	2222	3322	5111	2221	2223	3222	2211	2222
9	5332	5553	5553	5555	5522	**5211**	**1111**	2221	2221	2222	5222	2222
10	2222	5432	5543	5555	5522	3221	2211	2211	5533	5221	2111	2211
11	5555	5544	5543	5555	5532	2221	3221	3221	3222	5322	1111	2222
12	2222	5532	5553	5555	2222	5222	1000	3222	5222	3322	**2111**	3322
13	5532	5554	5332	5555	2211	2211	5211	5221	2211	5522	2221	5222
14	5532	5555	5555	5555	2222	2221	5521	3332	3322	2222	2221	2222
15	3222	4333	5543	5555	5552	5221	2111	2221	3322	2222	2222	5555
16	5554	4443	5533	5553	5555	2222	2211	2221	3322	5222	2211	2111
17	2222	5544	5555	5555	5553	2222	2221	5521	2222	5332	5211	2222
18	5432	5553	5555	5322	2111	1111	2221	5522	3222	5222	5111	5222
19	5555	5543	5555	5555	2211	2111	1100	3222	2222	5532	2212	5522
20	5532	5555	5555	5533	3222	5221	2211	5221	2222	2221	5322	2222
21	5542	5555	5555	5532	2222	2211	2111	3222	3222	5222	2222	5222
22	5322	5555	5544	5555	2222	3332	2221	5211	3222	2222	2222	2222
23	5543	5555	5555	5555	2221	5522	5221	5221	5522	5333	2222	2222
24	5522	5555	5555	5555	5222	**5321**	2110	2222	3333	2221	2211	5222
Total count per tree	327	423	416	445	244	210	151	219	236	252	185	230
Average count per treatment		403				206				226		

[a] For method of counting and rating see text, page 94-95.

[b] The four leaves with greatest infection were selected for rating on each shoot; each numeral in the figure represents the rating of one leaf. The total rating for the shoot is the sum of the separate leaf ratings: e. g. 3+2+2+2=9.

Table 3. Effect of Agrimycin on peach bacterial leaf spot, as indicated by leaf spotting and defoliation on treated and untreated trees. Flaming Gold variety, Mountain Grove, Missouri, 1955.

Treatment	Control trees				Agrimycin							
					50 ppm				100 ppm			
Tree no.	1	2	3	4	1	2	3	4	1	2	3	4
Shoot no. 1	3322[b]	5432	5532	3222	5522	2222	2222	3222	5522	5552	3222	2111
2	2222	5222	4432	5433	5222	5322	1111	2222	5222	2222	5211	5555
3	5333	5555	5433	5553	5211	2222	2222	5222	5522	1111	5222	5522
4	2222	5533	5555	5554	5222	2211	2221	3222	2221	2211	5521	2222
5	4422	2222	5555	5332	2111	2222	1111	3222	1111	2223	5222	2211
6	5433	3222	3322	5522	2221	2222	5222	1100	2222	1111	1111	2211
7	3222	5332	4433	5532	5222	2222	5222	2222	5222	5222	1111	2221
8	3322	3222	4433	3222	2222	2222	2211	5532	1100	5221	5522	5111
9	5555	5432	5322	5532	1100	2222	2221	5222	2222	2211	1111	5110
10	5332	2222	5433	2222	2221	2222	2221	2222	1111	2222	1111	1111
11	5445	5321	5553	3222	2222	2212	2211	5221	1111	2222	1111	2110
12	4332	3222	5555	2222	2222	5322	1111	2222	2222	2221	5522	1111
13	3322	5332	3332	5444	5322	2222	2222	2222	2222	5222	2111	5552
14	3333	5532	5544	3333	5522	2223	2211	3222	1111	5222	5521	2222
15	5222	5522	5555	5322	2221	3332	5522	2211	1111	5221	2221	5222
16	5222	5222	5553	5332	2222	2222	5221	2211	1111	2222	2111	2222
17	5332	2222	3222	2222	3222	2222	2222	5522	2222	5222	5555	2111
18	5555	2222	5555	5555	5522	3322	2211	3322	3222	5211	2111	2222
19	2222	5222	5432	5532	5222	5222	2222	2222	1111	5222	1110	2222
20	5555	5222	5422	5322	2221	2222	5222	5222	1111	2222	5211	5222
21	5333	5555	5333	5544	5222	2222	5221	2222	2211	2222	5521	2221
22	5222	5322	5555	5543	2222	3222	2111	2222	2222	2223	2221	2211
23	5223	5332	5322	5555	3222	2211	2222	5332	2222	5552	1111	5222
24	3322	4432	4443	5555	2222	3322	2111	5553	2211	2222	2211	5521
Total count per tree	301	291	371	337	219	207	182	227	168	219	193	196
Average count per treatment	325				209				195			

[a], [b] See Table 2.

Table 4. Effect of Agrimycin on peach bacterial spot, as indicated by leaf spotting and defoliation on treated and untreated trees. Elberta variety, Mountain Grove, Missouri, 1955.

Treatment		Counts[a] of leaf lesions and missing leaves on trees receiving indicated treatment											
		Control trees				Agrimycin							
						50 ppm				100 ppm			
Tree no.		1	2	3	4	1	2	3	4	1	2	3	4
Shoot no.	1	5555[b]	5555	3333	5555	2222	1111	2111	5222	3222	2111	5522	2221
	2	5555	5222	5222	3322	2222	2211	5111	5552	3322	5511	1111	2111
	3	5552	4333	3332	5555	2221	5432	1111	3322	5322	2111	5552	3111
	4	5554	4443	4333	5332	2211	2222	5111	1111	2111	5211	5521	5555
	5	5533	5555	2222	4333	2211	5543	5111	2222	2111	2221	2111	2111
	6	5555	4432	5544	5555	5211	2222	2221	3322	3221	5511	2111	1111
	7	5555	5552	5555	5533	5555	2222	2211	5222	2221	5221	2211	5211
	8	5555	5555	5553	5552	5555	2211	2211	2111	2222	1111	5111	1110
	9	5553	4433	5332	5555	2211	1111	3322	3222	2211	5522	1111	2111
	10	5543	4433	3322	4322	5211	5211	1111	5511	2222	1111	5111	1111
	11	5555	4322	3322	5553	2222	1111	1111	2221	5552	5511	2111	1110
	12	3322	5553	3332	3222	5532	5211	2221	2221	5222	2211	2111	2211
	13	5555	3322	5555	5555	5111	1111	1110	5322	3322	1111	2111	5221
	14	5555	5222	2221	5322	5211	2111	1110	2211	5222	5511	2111	2111
	15	5555	4443	5533	5533	1111	2111	1111	3322	2222	2111	1110	5111
	16	5543	5555	5222	5555	2111	1111	2111	5552	3222	2111	2111	5555
	17	5554	5555	5533	5432	3211	3322	1111	2222	2221	1111	1111	5111
	18	4444	3322	3222	5533	1111	5211	1100	3222	1111	2221	5211	5552
	19	5555	2222	5533	5555	1111	1111	1111	5322	5222	2211	5211	5222
	20	5555	3322	3322	5555	5111	5211	5111	2211	5221	2222	1111	5222
	21	5555	3322	4433	5442	1111	2211	2111	3222	2222	1111	1111	5211
	22	5555	5443	2222	5555	2111	5555	2222	552;	3221	1111	1111	2111
	23	5555	5443	2222	5555	5211	3333	1111	2222	5522	2211	5551	5511
	24	5555	5555	2222	5432	2111	2222	2211	2111	2211	2211	2211	1111
Total count per tree		449	352	298	374	194	192	132	236	212	170	168	197
Average count per treatment			370				189				187		

[a, b] See Table 2.

Table 5. Effect of Agrimycin on peach bacterial spot, as indicated by leaf spotting and defoliation on treated and untreated trees. Hale Haven variety, Mountain Grove, Missouri, 1955.

Treatment	Counts[a] of leaf lesions and missing leaves on trees receiving indicated treatment											
	Control trees				Agrimycin							
					50 ppm				100 ppm			
Tree no.	1	2	3	4	1	2	3	4	1	2	3	4
Shoot no. 1	5555[b]	2122	5322	5555	5422	2222	5322	5522	5222	2222	3332	2222
2	5522	2222	2222	5555	2222	5222	2221	2222	3322	2222	5522	5333
3	3222	3224	3222	5222	5522	2111	2222	2221	5222	2211	5222	5522
4	5522	5532	5322	3222	4422	2111	5532	5522	3222	5211	1111	5522
5	4322	5552	2211	5555	5522	2222	5322	3222	3211	2222	2200	3221
6	4433	3222	2111	5532	5222	1100	5222	5222	2222	2211	5222	2222
7	3322	3222	4322	5555	5553	3222	5532	5511	5522	2211	5554	2222
8	3222	5521	5322	5555	5552	3222	5222	5221	5222	5222	5532	3222
9	5543	5522	4322	5221	1100	2221	2110	5522	2222	2222	2222	3222
10	5522	3222	3322	2222	2211	2211	5222	2222	3222	5222	5211	2211
11	5522	2222	2222	4322	1110	2222	1100	5322	5222	5222	5522	2222
12	5532	5522	5322	5222	2222	2211	2211	5533	2222	2221	3222	3222
13	5433	5322	3222	5555	2222	2221	3222	5522	2221	5222	5332	3322
14	5555	3222	3322	3333	5332	2221	5221	2222	2223	5222	5522	5555
15	5554	5222	5322	2221	2222	2222	5522	2211	2222	3222	5222	5222
16	5555	5332	4433	5222	2222	2222	2222	2222	2211	2211	5222	2211
17	5443	5522	3222	4432	4422	2222	3222	2222	2222	2221	5553	2211
18	5555	5521	5532	3332	2200	5222	1111	2221	2222	2211	2221	2221
19	5322	2222	4222	4333	5542	2222	5111	5555	5211	5522	3322	5522
20	5543	5522	5522	3122	2211	2222	5322	5512	5222	5222	3332	5522
21	4222	5222	2222	4322	1000	4322	5522	2222	2222	2221	5322	2222
22	4432	2221	3222	5222	2221	2211	5532	5532	5552	2221	5222	2211
23	3322	5221	5222	5544	2223	2221	5322	3222	2222	2111	2222	2211
24	5332	5552	3332	5552	2233	2222	2221	3322	2221	2221	2111	3211
Total count per tree	348	276	246	322	223	181	237	261	223	200	258	227
Average count per treatment		298				225				227		

a, b See Table 2.

Table 6. Effect of Agrimycin on peach bacterial spot as shown by extent of defoliation on treated and untreated trees. Counts made August 22-23 at Mountain Grove, Missouri, 1955.

Variety and treatment	Defoliation counts[a] Tree number 1	2	3	4
Flaming Gold				
checks	68	81	89	65
7 sprays - 100 ppm	7	17		
5 sprays - 100 ppm	10	9		
7 sprays - 50 ppm	13	6		
5 sprays - 50 ppm	20	35		
July Elberta	1	2	3	4
checks	87	68	72	88
7 sprays - 100 ppm	3	7		
5 sprays - 100 ppm	8	5		
7 sprays - 50 ppm	7	1		
5 sprays - 50 ppm	10	11		
Elberta	1	2	3	4
checks	76	82	83	96
7 sprays - 100 ppm	2	8		
5 sprays - 100 ppm	14	3		
7 sprays - 50 ppm	30	0		
5 sprays - 50 ppm	27	4		
Hale Haven	1	2	3	4
checks	75	37	64	88
7 sprays - 100 ppm	2	12		
5 sprays - 100 ppm	8	5		
7 sprays - 50 ppm	18	-		
5 sprays - 50 ppm	1	6		

[a] Highest possible defoliation count per tree would be 96 (4 leaves x 24 shoots).

3. There does not appear to be a significant difference in severity of defoliation between the treated trees with respect to either number or concentration of sprays.

Discussion

There are several phases of this work that might well bear closer scrutiny, aside from the results that have been presented herewith.

First, we might ask why was the spray schedule initiated 4 weeks after bloom? This date was not selected arbitrarily, rather it was chosen to take advantage of the low temperatures and concomitant slow bacterial growth that prevails when infections occur in early spring. In addition Larsh and Anderson (2) presented data suggesting that leaf infections did not appear in 1940 in south-central Illinois until sometime between April 22 and May 9 and then only to a limited degree. These dates are in good agreement with Rolfs' (3) observations in his early work also conducted at the Mountain Grove Fruit Experiment Station. Our intent, therefore, was to initiate the spray schedule as late as possible, extending it as close as possible to harvest with a minimum number of applications.

Since Dunegan as well as Rolfs placed considerable emphasis on precipitation as a prime disseminator of inoculum, extended periods of precipitation were taken as a guide by which each successive spray was applied. However, the minimum time interval between sprays, irrespective of the occurrence of precipitation, was 7 days. It is our opinion at this time that the extended period of precipitation requires further study with respect to determining the exact duration necessary to provide infection. Perhaps this "wet period" should also be correlated

with the existing temperatures in much the same manner that apple scab infections, Venturia inaequalis, are predicted.

Finally, this year's study was conducted in an orchard where there was no fruit. Although the incidence of disease, in treatments and controls, was adequately measured by the leaf spotting and defoliation syndrome, the effectiveness of the spray schedule in controlling fruit injury could not be ascertained. Of particular importance in this regard is determining the duration of the spray schedule and the number of sprays necessary to provide clean fruit.

Conclusions

The data presented indicate that under the conditions which prevailed at Mountain Grove, Missouri in 1955, Agrimycin appreciably reduced leaf spotting and defoliation induced by X. pruni. These results were obtained (a) when the spray program is initiated 4 weeks after bloom, (b) when succeeding sprays are applied after extended periods of precipitation, and (c) when the minimum interval between sprays is 7 days.

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UNIVERSITY OF MISSOURI, COLUMBIA, AND MISSOURI STATE FRUIT EXPERIMENT STATION, MOUNTAIN GROVE

FIVE COMPOUNDS TESTED FOR CONTROL OF MERION BLUEGRASS RUST[1]

Houston B. Couch and Herbert Cole, Jr.[2]

Summary

During the 1955 growing season, rust of Merion bluegrass, caused by Puccinia graminis Pers., was epiphytotic in many areas of Pennsylvania. Common Kentucky bluegrass plots growing next to heavily diseased Merion bluegrass plantings were completely free of rust.

Using a rust-diseased, first-year stand of Merion bluegrass, five compounds, including Acti-dione, Captan 50-W, Dithane D-14 + zinc sulfate, Dithane D-14 + zinc sulfate + copper sulfate, and Mathieson chemical 1456, were tested for rust control. Each compound was tested at 2 rates on 2 dates of application.

When applied at 15-day intervals, all compounds tested provided some measure of control. Acti-dione was most satisfactory, followed by the Dithane-zinc-copper formulation. Both of these compounds were phytotoxic.

Initially, the Merion variety of Kentucky bluegrass (Poa pratensis L.) was characterized as being highly resistant to Helminthosporium leaf spot and exhibiting a growth habit that enabled it to survive close mowing (2). These features, combined with an ability to grow well under relatively dry conditions and to withstand heavy tramping, have contributed greatly to the popularity of this selection.

The occurrence of rust on Merion bluegrass was first reported by Ray (4) in 1953. The extreme susceptibility of the Merion variety, in comparison to common Kentucky bluegrass, to the rust organism (Puccinia graminis Pers.) was brought out in this account. This marked difference in disease reaction has also been observed by Rogerson and King (5), and again by Ray (3) in 1955.

During the 1955 growing season, rust was the outstanding disease problem of Merion bluegrass in Pennsylvania. The disease was first observed in the University Park area the last week of July, and from August 20 to September 20 it occurred in epiphytotic proportions in this as well as many other sections of the State. In the experimental turf plots at University Park, Merion bluegrass plantings became so heavily diseased that they had a general reddish cast, while adjoining common Kentucky bluegrass plots were free of rust.

Concerning the chemical control of Merion bluegrass rust, Shurtleff (6) reported Dichlone-Maneb, Zineb, Acti-dione ferrated, and EMTS Turf Fungicide to be 97 to 100 percent effective in controlling the disease when applied as pre-inoculation sprays. In addition, he stated that Acti-dione ferrated, Maneb, and EMTS Turf Fungicide were 79, 71, and 61 percent effective respectively when applied 48 hours after inoculation.

Wallen (8), and Silverman and Hart (7) have obtained effective control of wheat stem rust (Puccinia graminis tritici Erickss. & Henn.) with Acti-dione. Hotson (1) has reported excellent control of wheat stem rust with soil applications of aqueous solutions of sulfamerizine. As post-inoculation sprays, he found the sodium salt of sulfadiazine, sulfapyrazine, sulfapyradine, and gantrasin (3, 4, dimethyl-5-sulfanilamide-isoazole) to control the disease effectively.

In the present investigation, Acti-dione (cycloheximide), Captan 50-W, Dithane D-14 (19% active ingredient) + zinc sulfate, Dithane D-14+ zinc sulfate + copper sulfate (3 parts zinc to 1 part copper), and Mathieson chemical 1456 [(disulfide of pyridinethiol, 1-oxide) 50% wettable powder] , were tested for control of Merion bluegrass rust (Table 1, column 1).

Each compound was tested at 2 rates, and on 2 dates of application (Table 1). This gave a total of 21 treatments, randomized through 6 replications. Each plot measured 4 feet 8 inches x 27 feet. Application of the material was made under 35 pounds pressure, using a boom-type, T-jet system, held 18 inches above the turf. All material was applied on the basis of dilution in 2 gallons of water per 1000 square feet. Triton B-1956 wetter and sticker was

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Table 1. Influence of various compounds on the development of Merion bluegrass rust.

Compound	Date of application[a,b]	Rate of Application per 1000 sq. ft.	Disease Rating
Check	0	0	1.8
Actidione	a	422 mg.	1.4
	a+b	422 mg.	0.7**
	a	844 mg.	1.4
	a+b	844 mg.	0.4**
Captan 50-W	a	2.5 lb.	1.7
	a+b	2.5 lb.	1.3*
	a	5.0 lb.	1.4
	a+b	5.0 lb.	1.0**
Dithane D-14+$ZnSO_4$ 3/4 lb. $ZnSO_4$/1 qt. Dithane	a	2 oz.	1.2**
	a+b	2 oz.	1.2**
	a	4 oz.	1.4
	a+b	4 oz.	1.3*
Dithane D-14+$ZnSO_4$ +$CuSO_4$ (3 parts Zn/1 part Cu) 3/4 lb. $ZnSO_4$/1 qt. Dithane	a	2 oz.	1.6
	a+b	2 oz.	1.1**
	a	4 oz.	1.2*
	a+b	4 oz.	0.8**
Mathieson 1456	a	10 gm.	1.5
	a+b	10 gm.	1.5
	a	20 gm.	1.5
	a+b	20 gm.	1.3*

L.S.D. .05 = 0.5
.01 = 0.6

a, b a = August 17, b = September 1.

used with each treatment at 2 ounces per 50 gallon of water.

The plot area consisted of a first-year stand of a fall seeding of Merion bluegrass. One week prior to the first fungicide application, the planting was sprayed with an aqueous urediospore suspension of Puccinia graminis. At the beginning of the investigation, rust infection was moderately severe and fairly well distributed over the area.

Disease incidence ratings were made 3 weeks after the second date of fungicide application. Sampling of each plot was accomplished in the following manner: A 15-foot sampling grid of twine was constructed so that it provided 15 1-foot square sections arranged in a linear fashion. Before sampling, the grid was placed over the center of each plot, with its long axis oriented with that of the area to be sampled. For each plot, 5 of the 1-foot sections were selected at random and 20 leaves taken from each. Using an infection scale reading from 1 to 5, based on percentage of leaf area covered by pustules, each 20-leaf sample was rated. The total 100-leaf rating for the plot was then computed by averaging the 5 samples. These data were subjected to analysis of variance.

When applied at 15-day intervals, all of the compounds tested provided some measure of rust control (Table 1). Acti-dione gave a reduction in disease incidence for both rates significant from the check at the 1 percent level. This degree of disease control was quite noticeable, with the Acti-dione-treated areas being much greener than the checks as well as most of the other plots. The amount of disease with the higher dosage of Acti-dione was signficantly less at the 1 percent level than the best control with the other compounds, with the exception of the 4 ounces per 1000 square feet application of the Dithane-zinc-copper formulation.

Acti-dione, at both rates, and the 4 ounce application of Dithane D-14 + zinc sulfate + copper sulfate were phytotoxic. The toxic effect of these compounds was generally apparent the third day after application and no longer evident after the first mowing and subsequent removal of affected leaves. Leaf symptoms were essentially the same for both materials, first appearing as chlorotic flecking of the lamina, with these spots eventually coalescing to form large, blanched, white areas. Tip burning of leaves was also quite prevalent. A response characteristic of the Acti-dione-treated plots alone was a pronounced retardation in growth, which lasted for a period of about 7 days.

Discussion

The apomictic condition of Merion bluegrass stabilizes both the agronomic and disease reaction features of the variety. It follows that the development of a disease-resistant strain possessing the characteristics originally described for the parent, particularly where the parasite is capable of hybridization, will be an extremely difficult problem. Chemical control of the rust disease of this variety, then, is of prime importance.

The performance of Acti-dione was highly desirable from the standpoint of disease control. The compound fulfilled the requirements of providing an extremely high level of disease control and being effective at low concentrations. The phytotoxicity of the material, however, presents a problem in adapting it for general use on Merion bluegrass plantings.

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SEED TREATMENT TESTS FOR CONTROL OF BARLEY LOOSE SMUT+

R. H. Porter[1]

The hot water treatment developed by Jensen (3) for the control of loose smut of barley (Ustilago nuda (Jens.) Rostr.) has never been extensively used, primarily because it reduces seed germinability and temperature control is difficult for large seed lots. The modified hot water method proposed by Kellerman and Swingle (4) and further modified by other workers (6) met with a similar response.

Within the past 5 years other methods for the control of loose smut have been tested and described. Paulus and Starr (5) tested eight antibiotics of which streptomycin sulfate gave the best results by reducing loose smut to one-half that from non-treated seed. Tyner (7, 8) and Tyner and Russell (9) used a 40-hour soak in 0.2% Spergon suspension and a 50 to 64-hour soak in water alone. Both treatments controlled the smut pathogen but reduced germination of the seed. Arny et al. (1) reported on differences in varietal response in barley to water soak treatments. Hebert (2) found that by soaking seeds first in water for about 6 hours and then sealing the seed in air-tight containers the loose smut pathogen could be completely eliminated. He reported that seeds sealed, after soaking, at 24° and 28° C for 42 and 31 hours respectively produced smut-free plants. He indicated that the anaerobic condition in the sealed containers was largely responsible for the death of the pathogen. Seed germination was not materially reduced by the treatment.

Because of the common occurrence of several seed and soil-borne organisms that attack barley it seemed advisable to seek for a liquid chemical treatment that would not only control such pathogens but loose smut also.

EXPERIMENTAL RESULTS

Tests in 1954

A series of tests was initiated with two lots of barley designated as B6 (Lico) and B26 (from Canada). Both lots of seed were harvested from fields in which loose smut was prevalent. Lot B6 was divided into 9 sub-samples of 100 grams each and treated as indicated in Table 2. Lot B26 was divided into 4 sub-samples and treated as indicated in Table 3.

All treatments were made in the laboratory at room temperature which varied from 67° to 74° F. All samples that were sealed were placed in small Erlenmeyer flasks, filled to the top, and corked for the number of hours listed in Tables 2 and 3. Plantings were made in April in 20-foot rows with 20 inches between rows. The design was a randomized block with 4 replications of each sub-sample using 15 grams of seed per row.

Germination of the barley was reasonably uniform except in the rows planted with Spergon-tested seed. When the plants were nearly mature only those in rows planted with non-treated and Spergon-treated seed were pulled and counted in order to determine the degree of injury from the treatments with Spergon. The results are given in Table 1.

Table 1. Effect of treatment with Spergon on germination of early seed, 1954.

Treatments		Mean number of plants per row	
		Lico (B6)	B26
Check	None	369	405
Spergon 0.2% 48-hour soak	Planted two months after treatment	96	150
Spergon 0.2% 48-hour soak	Planted a few hours after treatment	6.5	

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Seed treated with Spergon and planted a few hours after treatment produced 1.8 percent as many plants as the non-treated seed. Spergon-treated seed planted 2 months after treatment produced 26 and 37 percent as many plants as non-treated seed of varieties Lico and B26 respectively. The plants from the latter treatments for lots B6 and B26, respectively, stooled abundantly. The heads were larger than in the check rows, which compensated in part for the reduction in germination.

The number of heads with loose smut was determined for all treatments and the results are given in Tables 2 and 3.

Table 2. Effect of seed treatments on loose smut of barley, variety Lico (B6) 1954.

Treatments per 100 grams of seed		Mean number smutted heads per treatment
1. Check	None	17
2. Panogen	0.12 ml., corked in flask 48 hours	19
3. Panogen	0.12 ml. in 6 ml. water, corked in flask 48 hours	16.2
4. Panogen	0.12 ml. in 12 ml. water, corked in flask 48 hours	12
5. Spergon	0.2% suspension, soaked 48 hours. Planted about 4 hours after treatment	0
6. Aureomycin	25 pp. million - soaked 24 hours	19
7. Magnamycin	25 pp. million - soaked 24 hours	25.8
8. Terramycin	25 pp. million - soaked 24 hours	19.8
9. Spergon	0.2% suspension, soaked 48 hours 2 months before planting	0

Table 3. Effect of seed treatment on loose smut of barley, variety B26, 1954.

Treatments per 100 grams of seed		Mean number smutted heads per treatment
1. Check	None	9.5
2. Merculine	0.12 ml. in 84 ml. water - 24 hours	4.2
3. Panogen	0.12 ml., corked for 48 hours	2.2
4. Spergon	0.2% suspension, soaked 48 hours two months before planting	0

The data in Tables 2 and 3 indicate that the Spergon-soak treatments were the only ones that controlled loose smut completely. No statistical analysis of the data was made. An analysis involving smut control evaluation is of value only when the number of infected plants is known. One seed in a lot may be infected and produce 1 to 15 or more smutted heads whereas in some cases only 1 or 2 smutted heads develop from one infected seed. The only valid criterion, therefore, is consistent reduction of smut to zero or nearly zero by a treatment in comparison with a relatively large number of smutted heads produced by non-treated seed.

Tests in 1955

Seed of the variety Lico was selected for a series of experiments in the spring of 1955. This variety is highly susceptible to loose smut and the seed used was from a field grown in 1953 in which loose smut was common.

Experiment No. 1: One lot of seed was divided into 6 sub-samples of 125 grams each and treated as listed in Table 4. At the close of each treatment the seeds were dried in the laboratory and placed in envelopes for later use in field planting. There were 3 replications of each treatment in 16-foot rows, with 20 inches between rows. Ten grams of seed was planted per row on April 5. Later a germination test was made in the greenhouse using a pasteurized sand and soil mixture. On July 7 the plants were pulled and counts made for smutted heads and total plants per row. Table 4 shows the results obtained from this test.

Table 4. Effect of seed treatments on germination and loose smut of barley (Lico), 1955.

Treatments per 125 grams of seed		% Germination Greenhouse	Means per treatment	
			Plants	Smutted heads
1. Check	No treatment	94	154.6	6
2. Panogen	0.15 ml. plus 10 ml. water - sealed 88 hrs.	88	124.6	1
3. Panogen	0.15 ml. plus 20 ml. water - sealed 88 hrs.	86	129	1
4. Spergon	0.2% suspension - soaked 4 hrs., removed from suspension and sealed 20 hrs.	92	117	4.6
5. Spergon	0.2% suspension - soaked 19 hrs., removed from water and sealed 20 hrs.	83	111	33
6. Water	Soaked 2 hrs., removed from water and sealed 23 hrs.	86	111.6	0

The amount of smut in rows from non-treated seed was not high enough to evaluate the treatments except that with water which eliminated the smut fungus from any infected seeds. Complete control by water alone may be due to the longer period during which the seeds were sealed under partially anaerobic conditions. The Panogen treatments are of interest in that they indicate that long periods of sealing in flasks do not seriously reduce germination when small quantities of water are used. None of the treatments had a serious effect on germination and the extra stooling with fewer plants could easily compensate for the reduced number of plants.

Experiment No. 2: A second lot of Lico barley seed was prepared in the same way as described for Experiment No. 1 except that 150 grams of seed was used for each treatment. The treatments are given in Table 5 together with other data.

Seed from each treatment was planted in rows 30 feet long using 4 replications. Each row was planted with a Planet Jr. drill and received about 20 grams of seed. Each 4 rows of a treatment were planted in succession, followed by those of another treatment. The date of planting was April 30. On July 18 all plants were pulled and counts made for total number of plants and total smutted heads. A greenhouse test for germination was also made and the results are presented in Table 5.

The results from Experiment No. 2 are more significant than those from the preceding experiments. The amount of smut in rows from non-treated seed is high enough to indicate that many seeds were infected, whereas the number of heads in rows from treatments 2, 3, and

Table 5. Effect of seed treatments on germination and loose smut in barley (Lico), 1955.

Treatments per 150 grams seed		% Germination Greenhouse	Means per treatment	
			Plants	Smutted heads
1. Check		94	174.2	14.8
2. Panogen	0.18 ml. in 130 ml. water soaked 2 hrs., removed from solution and sealed 20 hrs.	91	167.2	1.2
3. Spergon	0.2% suspension - soaked 2 hrs., removed from suspension and sealed 23 hrs.	86	93.3	0.75
4. Spergon	0.2% suspension - soaked 4 hrs., removed from suspension and sealed 20 hrs.	90	132.5	4.0
5. Water	Soaked 2 hrs., removed from water and sealed 23 hrs.	86	105.8	1.0

5 is so small that only one or more seeds could have retained viable mycelium. Also of interest is that the Panogen treatment was made with more water than previously used with this fungicide. The seeds were completely immersed in the solution for 2 hours before they were sealed under partially anaerobic conditions. Furthermore the Panogen treatment did not reduce field germination.

Experiment No. 3: In this experiment the sub-samples of seed contained 125 grams, each treated as shown in Table 6. After each treatment was completed, the seeds were dried, placed in envelopes and used later in planting. A germination test was made in the greenhouse using 2 replications of 100 seeds each in a mixture of pasteurized soil and sand. The field planting was a Latin Square arrangement with 5 replications of 4 rows per treatment, each row 10 feet long and 1 foot between rows. The seed was planted April 13 with a Planet Jr. drill calibrated to plant approximately 5 grams of seed per row. All replicates of a given treatment were planted before a second lot of treated seed was used. Soil moisture was deficient and irrigation water was not available until some seedlings had emerged. The stand was uneven and the plants did not all ripen at the same time, consequently the variability in yield was high.

At the time of harvest in July the two middle rows of each replicate were trimmed to 8 feet in length, cut by hand and tied in a bundle for threshing. Counts for the number of smutted heads were made in the 4 rows (40 feet) of each replicate. Later the grain from the two center rows was threshed and the weight determined in grams. All the data are presented in Table 6.

Table 6. Effect of seed treatments on germination, loose smut and yield of barley (Lico), 1955.

Treatments per 125 grams seed		% Germination Greenhouse	Means per treatment	
			Smutted Heads	Yield Grams*
1. Check		93	16.2	802.5
2. Panogen	- 0.15 ml. plus 10 ml. water sealed 48 hrs.	96	3	810.8
3. Panogen	- 0.15 ml. plus 20 ml. water sealed 48 hrs.	90	3.8	715.2
4. Spergon	- 0.2% suspension - soaked 2 hrs., removed from suspension and sealed 23 hrs.	96	3	730.2
5. Water	Soaked 4 hrs., removed from water and sealed 20 hrs.	91	7.2	671.2

*The "F" value for treatment/error was 0.54.

The Panogen treatments and the Spergon treatment reduced the number of smutted heads significantly but not sufficiently for practical use. It is important, however, to note that seed germination was not injured by any of the treatments. Furthermore, none of the treatments reduced or increased yield significantly, as determined by the analysis of variance, even though the rate of seeding was the same, which is of considerable significance. One of the problems in the control of loose smut has always been seed injury which necessitated a heavier rate of seeding than with non-treated seed.

EVALUATION OF TESTS IN 1954 AND 1955

In 1954 the only treatment that consistently eliminated loose smut from barley seed was the Spergon-soak for 48 hours, but germination was seriously reduced. The Panogen treatments with seed of variety B26 corked for 48 hours reduced smut appreciably but not adequately for practical use. No water was added to the commercial Panogen solution.

In 1955 the water treatment used in Experiment No. 1, which consisted of a 2-hour soak followed by retention of the seed in a corked flask for 23 hours, reduced smut to zero. The two Panogen treatments, which were diluted with small amounts of water, materially reduced smut but the number of smutted heads from non-treated seed was so low that the reduction may have been due to chance. The Spergon treatments as used were relatively ineffective due no doubt to insufficient length of time sealed in flasks.

The results obtained from Experiment No. 2 in 1955 are of particular significance because the number of smutted heads from the non-treated seed was fairly high and the length of time the treated seeds were sealed in flasks ranged from only 20 to 23 hours. In addition the Panogen treatment contained enough water to immerse the seeds completely during the 2-hour soak. The Panogen, one of the Spergon, and the water treatments nearly eliminated smut with little or no effect on seed germination. Hebert's (2) results would indicate that had the length of time the seed was corked in flasks been prolonged to 30 or more hours in the preceding tests complete control of loose smut would probably have resulted from the Panogen, Spergon, and water-soak treatments.

Advantages from the use of Panogen are that it is easily diluted with water and that it controls covered smut (Ustilago hordei (Pers.) Lagerh.) and stripe (Helminthosporium gramineum Rabh.). It is also recommended for partial control of seedling blight and root rot caused by Helminthosporium sativum Pam., King, & Bakke. A disadvantage of Spergon is that the dust does not remain in suspension well. Seed soaked only in water retains no fungicidal residue for protection from soil-borne organisms. It may be that the water-soak treatment will also control the covered smut and stripe pathogens but data on this phase of the problem have not been obtained.

The encouraging results obtained in 1955 with Panogen diluted in water have led to additional experiments made in the laboratory with five varieties of barley, namely Colsess, Lico, Lico II, Lico III, and Moravian.

Table 7. Effect of seed treatment with Panogen on germination of barley seed, 1955.

Variety	Year Grown	Percent Germination	
		Non-treated	Treated
Lico	1953	94	90.5
Lico II	1952	90.5	85
Lico II	1953	93	84
Lico III	1953	92	80
Lico III	1955	96.5	92.5
Colsess	1953	88	80.5
Colsess	1955	99.5	95.0
Moravian	1955	98	87

In November 1955, seed of these barley varieties was treated with Panogen, using 0.15 ml. in 150 ml. of water for 125 grams of seed. The seed was soaked 4 hours, drained, and corked in Erlenmeyer flasks for 36 hours at a temperature of 80° F. At the termination of each treatment the seed was dried and 200 seeds from each lot were tested for germination and the remainder placed in envelopes for later use in field planting. The results of the germination test are given for each variety in Table 7.

It is noteworthy that no serious reduction in germination occurred from any of the treatments, hence no adjustment in seeding rates would be necessary. The number of hours that the treated samples were sealed should be sufficient to completely kill the loose smut organism.

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COLORADO AGRICULTURAL EXPERIMENT STATION

SEED TREATMENTS FOR STRIPE AND COVERED SMUT OF BARLEY

R. H. Porter[1]

Summary

Tests for two seasons with seed of barley varieties infected with Helminthosporium gramineum and Ustilago hordei showed that new fungicides applied to the seed are able to control both diseases effectively as compared with no treatment. Ceresan M (an old treatment), Emmi, Merculine, Merlane, and Panogen all reduced the incidence of stripe to a low figure in 4 replications in 1954. Only the Ceresan M and Panogen, however, gave a significant increase in number of plants over the checks. Emmi at the concentration used reduced germination to 59 percent that of the checks. In 1955, Ceresan M, Merlane, and Panogen effectively controlled stripe, but none of the three significantly increased or decreased the yield over the checks.

In 1954, Panogen diluted 1 part to 100 parts of water and a 0.2% suspension of Spergon controlled covered smut. In 1955, Merlane, Merculine, and Panogen controlled covered smut effectively without significantly increasing or decreasing the yield in comparison with the checks. The uneven germination caused by inadequate soil moisture in some parts of the plot in 1955 caused considerable variation in yield of the replicates.

Barley stripe caused by Helminthosporium gramineum Rabh. has occurred to the extent of 30 percent infection in varietal trials at the Agronomy Farm of the Colorado Agricultural Experiment Station. Colsess, Lico, Lico II, and Lico III are among the varieties most commonly affected. The disease occurs occasionally in fields on Colorado farms. Covered smut caused by Ustilago hordei (Pers.) Lagerh. also occurs frequently in fields in eastern Colorado. Infected plants are often severely stunted and the smutted heads are partially enclosed by a leaf. As a result diseased plants are commonly unnoticed.

New compounds available on the market for treatment of cereal seeds necessitate a frequent appraisal of their value for the control of specific diseases. It seemed advisable, therefore, to undertake a series of tests using the infected seed available.

EXPERIMENTS WITH BARLEY STRIPE

1954 Experiments

In a varietal test plot of barley grown at the Agronomy Farm in 1953 it was noted that many of the varieties were characterized by a high percentage of plants infected with the stripe pathogen. Seed from 10 of the varieties was obtained for planting in 1954. Each lot was subdivided into 8 sub-samples of 110 grams each for treatment as follows:

1. Check -- no treatment
2. Ceresan M (1 part to 4 parts talc) -- 2 oz. per bu.; 0.28 grams per 110 grams of seed
3. Dithane -- 2 oz. per bu.; 0.28 per 100 grams of seed
4. Emmi (1 part to 3 parts talc) -- 2 oz. per bu.; 0.28 grams applied to 110 grams of seed
5. Merculine -- 0.13 ml. in 0.9 ml. water corked 48 hrs; applied to 110 grams of seed, equals 0.75 fluid ounces per bushel
6. Merlone -- 2 oz. per bu.; 0.28 grams applied to 110 grams of seed
7. Panogen -- 0.13 ml. to 110 grams of seed, corked 48 hrs.; equals 0.75 fluid ounces per bushel
8. Vancide -- 4 oz. per bu., 0.57 grams per 100 grams of seed

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[1] Plant Pathologist, Colorado Agricultural Experiment Station. Published with the approval of the Director, Colorado Agricultural Experiment Station as Scientific Series Paper No. 470.

The data obtained in 1954 involved a tremendous amount of field work. Without the valuable assistance of Robert G. Hacker it would have been almost impossible to obtain the results. The thanks of the writer are gratefully extended for the assistance so generously given.

The chemical names for the 7 compounds used are as follows:

2. Ceresan M -- N-(ethylmercuri)-p-toluenesulfonanilide
3. Dithane -- zinc ethylenebis dithiocarbamate
4. Emmi -- 1, 4, 5, 6, 7.7-hexachloro-N-(ethylmercuri) bicyclo 2.2.1 hept-5-ene-2, 3-dicarboxamide
5. Merculine -- phenylmercury salicylate
6. Merlane -- phenylmercury acetate; ethyl mercury chloride; -1, 2, 3, 4, 5, 6-hexachlorocyclohexane
7. Panogen -- cyano (methyl mercuri) guanidine
8. Vancide -- sodium dimethyldithio carbamate; sodium derivative of 2-mercaptobenzothiazole

The varieties used in this test were:

A. Atlas, 6-row, bearded
B. Colsess, 6-row, hooded
C. C. I. 5461, 6-row, bearded
D. Lico, 6-row, bearded
E. Lico II, 6-row, beaded
F. Lico III, 6-row, bearded
G. Plains, 6-row, bearded
H. Scotch, 6-row, bearded
I. Velvon, 6-row, bearded
J. Wis. 571, 6-row, bearded

Following each treatment, 4 samples of 16 grams each were prepared from each treatment lot for each of the 10 varieties and planted in 20-foot rows with 20 inches between rows. The planting plan consisted of a split plot design with the replications serving as the main blocks. Seed of the 10 varieties (each with 8 treatments) was planted in the 4 blocks (replications), with varieties randomized. The treatments for each variety were also randomized. There were 80 rows in each replicate and 320 rows in the entire plot.

In late July when the grain was nearly ripe all plants were pulled and examined. The total number of plants (each from a single seed) and the number of plants showing the stripe disease were determined and recorded for each row. The results are given in Tables 1 and 2.

The data were treated statistically by an analysis of variance and least significant differences at the 0.01 and 0.05 levels for mean number of plants per replicate by treatments are given in the tables. A careful study of Table 1, which gives response by varieties, shows that treatments 2, 4, 5, 6, and 7 gave good control of the stripe disease, and for some varieties the same treatments, except No. 4, gave a significant increase in the number of plants per replicate in comparison with the check. Treatments 3 and 8 were generally effective insofar as an increase in stand is concerned but they were ineffective for the control of stripe. There was a considerable amount of root rot in the plots and the increase in stand resulting from treatments 3 and 8 was no doubt the result of protection of the seed from root rot fungi. Plants with root rot generally showed leaf infection with Helminthosporium sativum Pam., King, & Bakke.

The data in Table 2 give an over-all summary of the results for all varieties based on statistical analysis. Treatments 2, 7 and 8 brought about a highly significant increase in total number of plants as compared with the check. Based on stripe control and beneficial effect on stand in the field only the Ceresan M and Panogen treatments gave consistently significant results. Emmi (No. 4) gave good control of the stripe disease but reduced the stand significantly. The proper concentration of this fungicide needs further study.

Experiments in 1955

Seed of the barley varieties Colsess, Lico, and Lico II grown in 1953 was obtained from the Agronomy Farm. Each lot was divided into 4 sub-samples of 100 grams each and treated as follows:

No.	Treatment
1.	Check -- no treatment
2.	Ceresan M (1 part to 4 parts talc) -- 255 mg. used
3.	Merlane -- 320 mg. used
4.	Panogen -- 0.12 ml. plus 10 ml. water used and seed corked in a flask for 48 hours.

Table 1. Effect of 7 treatments on 10 varieties of barley for control of stripe, 1954.

Treatment.	Variety	Total Plants	Mean Per Treatment	Total Stripe	Variety	Total Plants	Mean Per Treatment	Total Stripe
1	A	1210	302.5	77	B	1228	307.0	107
2		1365	+346.2**	6		1618	+404.5**	2
3		1258	314.5	73		1316	+329.0**	91
4		622	-155.5**	5		595	-149.0**	1
5		1282	+320.5*	7		1401	+350.0**	5
6		1374	+343.5**	0		1494	+374.0**	5
7		1342	+335.5**	3		1416	+354.0**	2
8		1375	+344.0**	55		1521	+380.0**	51
1	C	702	178	33	D	1431	358	118
2		886	+221.5**	5		1473	368	1
3		847	+212**	21		1358	339.5	48
4		484	-121**	10		833	-208**	0
5		799	+200*	3		1354	-338.5*	5
6		865	+214**	2		1358	-339.5*	0
7		887	+222**	5		1493	373	2
8		922	+230**	20		1411	352	22
1	E	1325	331.2	109	F	1220	305	74
2		1334	333.5	2		1278	319.5	2
3		1326	331.5	122		1252	313	59
4		938	-234.5**	1		726	-181.5**	0
5		1242	-310.5*	5		1122	-285.5*	1
6		1192	-298**	1		1266	316.5	4
7		1319	329.8	2		1271	318	0
8		1341	335.2	56		1257	314	38
1	G	1254	314	86	H	1307	327	86
2		1318	329	6		1418	+355**	3
3		1376	+344**	64		1274	319	59
4		801	-200**	0		838	-209**	1
5		1237	309	13		1205	-301**	1
6		1334	+334*	4		1406	+351**	8
7		1489	+372**	0		1298	325	0
8		1330	+337*	46		1417	+354**	61
1	I	1020	255	74	J	1317	329	63
2		1248	+312**	4		1295	324	0
3		1156	+289**	59		1258	315	86
4		625	-156**	2		693	-173**	0
5		1061	265	5		1231	-308**	7
6		1229	+307**	4		1091	-273**	2
7		1219	+305**	0		1359	340	0
8		1230	+308**	48		1439	+360**	68

L.S.D. .01 = 24.6**
L.S.D. .05 = 18.67*

Table 2. Summary of effect of 7 treatments on 10 varieties of barley for control of stripe, 1954.

Treatments on ten varieties	Total plants	Mean number plants per treatment	Difference between mean numbers of plants	Total Stripe plants
1. Check	12014	300.4		827
2. Ceresan M	13233	330.8	+ 30.4**	31
3. Dithane	12421	310.5	+ 10.2	682
4. Emmi	7155	178.9	- 121.5**	20
5. Merculine	11934	298.4	- 2.0	52
6. Merlane	12609	315.2	+ 14.8	30
7. Panogen	13093	327.3	+ 26.97**	14
8. Vancide	13243	331.1	+ 30.7**	465

L. S. D. .01 = 24.6**

L. S. D. .05 = 18.67*

Table 3. Effect of 3 fungicides on stripe and on yield of 3 varieties of barley, 1955.

	Mean Numbers Per Treatment					
	Colsess		Lico		Lico II	
Treatments	Plants With Stripe	Yield in Grams	Plants With Stripe	Yield in Grams	Plants With Stripe	Yield in Grams
Check	11.75	352	5.25	679	4.25	645
Ceresan M	0.5	351	0	624	0	695
Merlane	0.5	465	0	618*	0	755
Panogen	0	408	0	659	0	718

F values determined from treatment/error were

Colsess 0.59 Lico 7.4 Lico II 0.31

L.S.D. .05 = 70.6*

Plantings were made at the Agronomy Farm April 13 and 14, 1955. Each variety with all treatments was planted as 1 unit in a Latin Square arrangement of 4 replications. Each replicate of a treatment consisted of 4 rows 10 feet long with 1 foot between rows. The seed was planted with a Planet Jr. drill calibrated to plant about 5 grams per row. The seed for a given treatment was planted in all replicates before another lot of treated seed was used. A large tire pump was employed to clean the hopper after each lot of treated seed was planted. Germination was irregular and somewhat uneven caused by lack of rain for several weeks, and irrigation water was not available until about 1 month after planting.

In late July counts were made in each row for the number of plants infected with the stripe fungus. The two middle rows of each treatment in each replicate were shortened to 8 feet, cut by hand, tied in a bundle and threshed separately. The data obtained from this experiment are given in Table 3.

Analysis of variance of the yield data was made for each variety, and in only one case were the differences significant as shown in Table 3. The high variability within and between replicates accounted for the lack of significant differences.

EXPERIMENTS WITH COVERED SMUT OF BARLEY

In 1954 a sample of barley from Winnipeg, Canada, was obtained for use in a cooperative seed treatment test. It was discovered that the sample carried a large amount of covered smut balls hence some tests with fungicides were undertaken as follows:

No.	Treatments per 100 grams of seed
1.	Check -- no treatment
2.	Panogen -- 0.12 ml. corked 48 hours
3.	Panogen -- 0.12 ml. in 6 ml. water, corked 48 hours
4.	Panogen -- 0.12 ml. in 12 ml. water, corked 48 hours
5.	Spergon -- 0.2% suspension, soaked 48 hours, 72° F.
6.	Aureomycin -- 100 mg. in 400 ml. water, soaked 24 hrs.
7.	Magnamycin -- 100 mg. in 400 ml. water, soaked 24 hrs.
8.	Terramycin -- 100 mg. in 400 ml. water, soaked 24 hrs.

The seed from each treated sub-sample was planted in 20-foot rows, 20 inches between rows using 16 grams of seed per row. There were 4 replications in a randomized block design. When the grain was nearly ripe counts were made for the number of smutted heads with the results shown in Table 4.

Table 4. Effect of seed treatments on covered smut of barley, 1954.

Treatment	Total Smutted Heads	Treatment	Total Smutted Heads
1	208	5	0
2	91	6	147
3	12	7	160
4	1	8	170

Germination of the seed was reasonably uniform for all treated lots with the exception of Spergon which reduced germination to 25 percent that of the non-treated seed. It is noteworthy that Panogen with no water added was relatively ineffective for covered smut control, but when diluted 1 part to 100 parts of water the control was practically complete. The 3 antibiotics were ineffective against covered smut.

In 1955 a planting was made at the Agronomy Farm using the seed harvested from rows planted with non-treated seed in 1954. Five treatments were used on each of 5 sub-samples, each containing 125 grams. The treatments were as follows:

No.	Treatments per 125 grams of seed
1.	Check -- no treatment
2.	Ceresan M -- (1 part to 4 parts talc) - 325 mg. used
3.	Merlane -- 400 mg. used
4.	Merculine -- 0.20 ml. in 2 ml. water, corked 48 hours
5.	Panogen -- 0.20 ml. in 20 ml. water, corked 48 hours

The plots for this test were planted April 12 in 10-foot rows, 1 foot between rows with 4 rows per replicate. There were 5 replications, each planted in a Latin Square design with a Planet Jr. drill calibrated to plant about 5 grams per row. All replicates for a given treatment were planted in successive order after which the hopper was cleaned with air blown in by a large tire pump before another treated lot was planted.

Table 5. Effect of seed treatments on covered smut and yield of barley, 1955.

Treatments	Total Heads Smut	Total yield (grams) 5 replicates	Mean yield per treatment
1. Check	311	2417	483.4
2. Ceresan M	16	2589	517.8
3. Merlane	1	2615	523.0
4. Merculine	0	2358	471.6
5. Panogen	0	2336	467.2

F value determined from treatment/error was 0.08.

When the grain was nearly ripe, counts were made for total covered smut heads in each replicate of 4 rows. The 2 center rows were trimmed to 8 feet in length, harvested, and tied in a bundle for threshing. The complete data from the experiment with covered smut in 1955 are given in Table 5.

Treatments 3, 4, and 5 proved highly effective in eliminating covered smut from seed of the barley variety used. It is probable that the Ceresan M was diluted too much with talc for complete control of the disease. Analysis of variance of the data indicated no significant differences in yield.

COLORADO AGRICULTURAL EXPERIMENT STATION

FACTORS CONTRIBUTING TO THE INCREASE OF DOWNY MILDEW OF BROCCOLI IN NEW YORK STATE AND ITS CONTROL WITH FUNGICIDES AND AGRIMYCIN[1]

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SUMMARY

The recent increase of downy mildew of broccoli in New York State appears to have resulted from the following causes: (i) extensive plantings of the downy mildew-susceptible variety Waltham 29, (ii) increase in inoculum as the result of the recent increase in acreage devoted to broccoli production plus the planting of a mildew-susceptible variety of broccoli during successive years, and (iii) creating conditions favorable for the germination of spores on the broccoli foliage by the application of emulsifiable insecticide formulations which remove the bloom from the leaves and possibly dissolve wax from the cuticle of the leaves.

A heretofore unreported systemic invasion of the apical portion of the broccoli plant by the downy mildew fungus is described.

In field tests, downy mildew was less severe in late-maturing varieties of broccoli than in early-maturing varieties. Differences in resistance to downy mildew independent of maturity of the plants was observed among broccoli varieties.

The incidence of downy mildew in plots of broccoli sprayed with emulsifiable insecticide formulations containing a solvent and a wetting agent was significantly greater than in plots sprayed with an insecticide formulation containing no solvent or wetting agent or in unsprayed plots.

Agrimycin and Spergon SL were the most promising materials for the control of downy mildew. Captan 90W, Dithane D-14 plus zinc sulfate, and fungicide B-622 were not effective under conditions of these tests.

INTRODUCTION

Downy mildew caused by Peronospora parasitica Pers. ex Fr. is becoming a problem of increasing concern to broccoli growers in central and western New York State. This disease undoubtedly has been present in this area for many years, but has not been considered of economic importance until recently. In 1954 and 1955, downy mildew of broccoli, although generally not severe, was destructive at scattered locations. Downy mildew, therefore, is a threat to the recently expanded broccoli industry in New York State.

In 1954, investigations were initiated to determine possible reasons for the recent increase in incidence of downy mildew of broccoli, and to test the possibilities of controlling downy mildew by application of fungicides incorporated with insecticide sprays.

Symptoms of downy mildew infection of broccoli including a heretofore unreported systemic invasion of the broccoli head by the mildew fungus, differences in susceptibility to downy mildew among commercial broccoli varieties in the field, influence of certain insecticide formulations on incidence of downy mildew, and control of downy mildew by various fungicides and with Agrimycin are presented in this report.

SYMPTOMS OF DOWNY MILDEW OF BROCCOLI IN THE FIELD

Downy mildew appears first on the lower leaves of broccoli plants. Leaf infection may occur soon after the plants are set in the field or may take place later in the season. Older leaves appear to be more susceptible than newly developed leaves. When the surface of the foliage is wet, the downy white mycelium of the fungus is readily observed on the under surface of the leaves.

The first symptoms of leaf infection are small water-soaked spots surrounded by a halo of light green tissue on the under surface of the leaf. Under conditions favorable for development of infection, the spots enlarge to form indefinite yellow areas. Later, the tissues within these infected areas collapse and become light brown and parchment-like. The mildew lesions vary

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Table 1. Relative susceptibility of eight varieties of broccoli to downy mildew, 1955.

Variety[a]	Source	Downy mildew ranking[b] Replicates A	B	C	D
Green Mountain	Ferry-Morse Seed Co.	8	8	8	8
Texas 107	Ferry-Morse Seed Co.	7	7	7	6
DeCicco	Ferry-Morse Seed Co.	3	3	3	3
Early Green Sprouting	Ferry-Morse Seed Co.	4	6	4	4
Midway	Assoc. Seed Growers, Inc.	6	5	5	5
Waltham 29	Ferry-Morse Seed Co.	5	4	6	7
Calabrese	F. H. Woodruff Seeds	1	1	2	1
Grand Central	Assoc. Seed Growers, Inc.	2	2	1	2

[a] Varieties listed in order of earliest to latest maturing variety.

[b] Numbers in table indicate ranking of variety according to severity of foliage infection: 1 = least infection; 8 = most severe infection.

in size and shape. The largest lesions usually are bounded by leaf veins. Yields from severely infected plants are reduced from the effects of leaf injury and defoliation.

The initial spots of infection may also remain localized. The tissues of the spot collapse to form a small brown lesion. These spots do not enlarge even under conditions favorable for infection.

The apical portion of some broccoli plants at harvest time was observed to be systemically invaded by the downy mildew fungus. This systemic infection was usually confined to the upper portion of the main stalk and to the branches leading to the florets of the head. Infected tissues were brown to black and firm, in some plants in the form of net-necrosis, and in others as long strands of discolored tissues. Infection was not restricted to any specific tissues. Mycelium and haustoria of the fungus were observed in sections prepared from the discolored tissues. Frequently, no external evidence of systemic infection was present. In some plants systemic invasion of the head could be detected by means of diffuse blue to purple areas on the stalk and branches of the head. Because of its hidden nature, systemic infection is of particular concern to the commercial packer of broccoli.

SUSCEPTIBILITY OF BROCCOLI VARIETIES TO DOWNY MILDEW IN THE FIELD

In a field test conducted in 1955, eight commercial broccoli varieties were observed for susceptibility to downy mildew under field conditions. The plants were started in the greenhouse, and transplanted to the field on August 1. Plantings were delayed for about 2 weeks in this plot because of drought conditions. The planting consisted of 4 replications of 25 plants each of each variety. Infections were the result of natural inoculum and prevailing environmental conditions. The plots were not sprayed with fungicides or insecticides. The first symptoms of downy mildew infection were observed on the lower leaves of some plants on September 14. The disease was present before this date since some lesions already had attained considerable size. On October 17, the varieties within each replicate were given a numerical rating according to the severity of leaf infection. The variety with the least foliage infection was given the rank of 1, and the rank of the other varieties followed in numerical order of increasing severity of foliage infection.

The results of this test (Table 1) show that the varieties Calabrese and Grand Central were the most resistant to foliage infection. Foliage infection in these varieties usually consisted of

scattered lesions on the lowest leaves. The variety DeCicco ranked next in order of resistance to downy mildew infection. The lower leaves of plants of this variety were severely infected, but the upper leaves were generally free from infection. This variety was considerably more resistant than Early Green Sprouting, Midway, and Waltham 29, which were moderately susceptible. The degree of foliage infection among plants of these varieties ranged from slight to severe so that no clear-cut differences between them were established. Foliage infection was present on both lower and upper leaves in most instances. The varieties Green Mountain and Texas 107 were the most susceptible. Foliage infection was severe on both lower and upper leaves. Defoliation was so severe that on some plants only a few top leaves remained.

The severe infection of the early-maturing Green Mountain and Texas 107 varieties, and the very light infection of the late-maturing varieties Calabrese and Grand Central, indicate that downy mildew resistance in broccoli is related to the maturity of the plants. However, the susceptibility of medium late variety Waltham 29, and the resistance of the early-maturing variety DeCicco, demonstrate that a form of resistance to downy mildew independent of maturity is present in some varieties of broccoli.

INFLUENCE OF INSECTICIDE SPRAYS ON INCIDENCE OF DOWNY MILDEW OF BROCCOLI

For the past 3 years, downy mildew has appeared to be more prevalent in plantings of broccoli sprayed with insecticides than in unsprayed plantings, but no data on the actual differences in incidence of downy mildew in sprayed and unsprayed plots were obtained. The following possibilities were considered as probable contributing factors to the observed increase in incidence of downy mildew in plots sprayed with insecticides: (i) distribution of spores of the mildew fungus by spraying, (ii) injury to the foliage by the insecticide which facilitated the entrance of the fungus into the plant tissues, and (iii) the dissolving of the bloom and the wax from the cuticle of the broccoli leaves which permitted the wetting of the foliage and provided conditions favorable for the germination of the mildew spores. Insecticide spray tests conducted in 1955 provided an opportunity to explore these possibilities.

Materials and Methods

Broccoli plants of the variety Waltham 29 were sprayed with various emulsifiable insecticide formulations containing both emulsifying agents and solvents, and with a technical grade of insecticide containing no emulsifier or solvent. Unsprayed plants served as controls. The sprays were applied by means of a sprayer calibrated to deliver 25 gallons per acre at 80 pounds pressure, at a tractor speed of 3 miles per hour. The treatment plots consisted of 2 adjacent 20-plant rows. A single untreated row separated the treatment plots. Each treatment was replicated 4 times. A total of 6 sprays were applied.

The influence of the sprays on the incidence of downy mildew was determined by obtaining the average number of mildew lesions per 9 square inches of leaf area per leaf, of 25 leaves from each replicate. Leaves to be scored for mildew were picked at random, one leaf from the central portion of each plant. Leaves from the lower portions of the plants contained too many lesions, and those from the upper portions too few, to obtain a satisfactory measure of differences in incidence of mildew in the various treatment plots. To obtain the number of lesions per 9 square inches of leaf area per leaf, a sheet of cellulose nitrate, from which a 3- x 3-inch area had been removed, was placed on the under surface near the center of the leaf, and the number of lesions within this area was counted.

Results

On September 20, broccoli plants sprayed with Shell OS 2046 at each dosage, Diazinon at the lowest dosage, and unsprayed plants averaged 20 to 21 lesions per leaf as described above. Plants sprayed with the other insecticide formulations averaged from 26 to 30 lesions per leaf. On September 27, broccoli plants sprayed with Shell OS 2046 at each dosage averaged 21 lesions per leaf; Diazinon at the lowest dosage, 23 lesions; and unsprayed plants, 20 lesions. The number of lesions from plants sprayed with the other insecticide formulations again was significantly greater than from the aforementioned treatments and that from unsprayed plants (Table 2).

Each of the insecticides, with the exception of Shell OS 2046, was an emulsifiable formulation containing both a solvent and an emulsifying agent. Shell OS 2046 is a water-soluble in-

Table 2. Influence of insecticides applied as foliage sprays on the incidence of downy mildew of broccoli.

Material[a]	Formulation, Lbs./gal.	Actual toxicant, Lbs./acre	Mildew lesions per leaf (Av. of 100 leaves) Sept. 20	Sept. 27
Shell OS 2046	10	0.25	20	21
Shell OS 2046	10	0.50	21	21
Shell OS 2046	10	1.00	21	21
Diazinon	2	0.25	21	23
Diazinon	2	0.50	26	31
Diazinon	2	1.00	28	30
American Cyanamid 3911	4	0.50	27	31
Malathion	5	1.00	27	32
Isodrin	1.6	0.50	29	28
Endrin	1.6	0.25	28	30
Parathion + TEPP	2.0 40% solution	0.25 ½ pt.	32	36
No treatment		—	21	20
Least difference required for significance		(19:1)	5	3
		(99:1)	7	4

[a] 6 applications: August 3, 24; September 2, 13, 21; and October 3.

secticide and contains neither solvent nor emulsifying agent. Plants sprayed with each of the emulsifiable insecticide formulations appeared to be yellowish-green, while the unsprayed plants were bluish-green. Plants sprayed with Shell OS 2046 were similar in appearance to unsprayed plants.

This test indicated that spraying was not responsible for the increase of mildew in plantings of broccoli sprayed with insecticides, since the incidence of mildew in plots sprayed with Shell OS 2046 was the same as that in unsprayed plots. The results did indicate that the increase in mildew in plots sprayed with emulsifiable insecticide formulations was related to the dissolving of the bloom and possibly the wax in the cuticle of the leaves by the solvent in the emulsion and, perhaps to some extent, to injury to the leaf by either the solvent or the emulsifying agent.

CONTROL OF DOWNY MILDEW OF BROCCOLI WITH FUNGICIDES AND WITH AGRIMYCIN

Investigations were conducted in 1954 and 1955, to test the possibilitities of controlling downy mildew of broccoli by means of incorporating a fungicide with the insecticide spray applied to the broccoli plants. Since insecticides must be applied periodically to broccoli plants in order to grow this crop successfully, the addition of a fungicide to the insecticide spray preparation appeared worthy of consideration as a method for controlling downy mildew.

Materials and Methods

1954 Tests: The fungicides Spergon SL (98% chloranil), Dithane D-14 (nabam) plus zinc

Table 3. Control of downy mildew of broccoli with fungicides and with Agrimycin, and the compatibility of these materials with an insecticide spray containing parathion and TEPP, 1954.

Materials[a]	Insecticide[b]	Mildew rating Oct.9	Mildew rating Oct.18	Av.no. aphids	Yield, tons/acre
Agrimycin	+	3.7	4.6	185	1.5
Agrimycin[c]	+	3.5	4.6	1028	1.7
Agrimycin	-	3.7	4.8	2447	1.3
Dithane + $ZnSO_4$	+	3.8	4.7	334	1.5
Dithane + $ZnSO_4$	-	3.8	4.7	2169	1.2
Spergon SL	+	3.2	4.3	271	1.6
Spergon SL	-	2.7	4.3	2865	1.2
No treatment	+	4.1	5.0	56	1.6
No treatment	-	4.1	4.9	2706	1.2
Least difference required for significance (19:1)		0.6	0.3		0.3
(99:1)		0.8	0.5		0.4

[a]Dosages: Agrimycin at 100 ppm or approximately 0.1 lb./acre; Dithane D-14 at 2 qts. plus zinc sulfate 3/4 lb./acre; Spergon SL at 2 lbs./acre.

[b]Insecticide consisted of parathion 1 pt. plus TEPP ½ pt./acre; + indicates treatments included insecticide; - indicates treatments did not include insecticide.

[c]This treatment was applied only 4 times. All other treatments applied 8 times.

sulfate, and the antibiotic Agrimycin (15% streptomycin and 1.5% oxytetracycline) were applied as foliage sprays alone, and in combination with an insecticide spray containing parathion plus TEPP. Sprays were applied by means of a tractor-mounted sprayer calibrated to deliver 20 gallons per acre at 80 pounds pressure. Later in the season, in order to obtain thorough coverage of plants, the volume of spray was increased to 35 gallons per acre.

All plants in this test were of the broccoli variety Waltham 29. Treatment plots consisted of 2 adjacent 20-plant rows. The individual plots within each replicate were separated by 2 untreated rows. Treatments were replicated 4 times.

The effectiveness of the materials in controlling downy mildew was determined by assigning to each of the 40 plants of each treatment plot a numerical rating ranging from 1 through 6 to indicate the severity of mildew infection. In this method of rating, a value of 1 indicated that the plant was free from infection; whereas values of 2, 3, 4, 5, and 6 indicated degrees of infection ranging from slight to severe. The total of the mildew ratings of each treatment was then determined and this value used in the statistical analyses. The plants were rated for mildew infection at the peak of the harvest.

The influence of the fungicide-insecticide combination sprays on control of cabbage aphids was also determined in order to obtain information on the mutual compatibility of the pesticides. Aphid control was determined by counting the number of aphids in a 2-pound sample of broccoli, which was obtained by massing portions from broccoli heads randomly picked from within each treatment plot.

1955 Test: The fungicides Spergon SL (98% chloranil), Captan 90W (90% captan), B 622 (50% 2,4-dichloro-6-(o-chloroanilino)-s-triazine), and the antibiotic Agrimycin 100 (15% strepto-

Table 4. Control of downy mildew with fungicides and with Agrimycin applied in low and high gallonage sprays, 1955.

Treatments[a]	Dosage, Lbs./acre	Spray, Gals/acre	Mildew lesions per leaf	
			Sept. 19	Oct. 5
Agrimycin 100	1.0	25	6	14
Agrimycin 100	1.0	100	6	15
Captan 90W	3.3	25	19	27
Captan 90W	3.3	100	18	28
Spergon SL	3.0	25	8	15
Spergon SL	3.0	100	9	17
B 622	6.0	25	25	28
B 622	6.0	100	25	29
No treatment	-	-	27	32
Least difference required for significance		(19:1)	4	4
		(99:1)	6	6

[a] Parathion at 1.0 lb. plus TEPP at 1/2 pt./acre included with all treatments. Insecticides applied on August 3, 24; September 2, 13, 21; and October 3. Fungicides applied on the last 4 dates only.

mycin plus 1.5% oxytetracycline) were used. These materials were added at the required amount to the insecticide spray which consisted of a combination of parathion and TEPP. Sprays were applied at a volume of 25 gallons per acre at 80 pounds pressure in some plots, and at a volume of 100 gallons per acre at 300 pounds pressure in others, in order to determine whether low or high gallonage methods of spray application would influence the effectiveness of any of the materials in controlling downy mildew. The amount of toxicant applied per acre was the same in both the high and low gallonage sprays.

All broccoli plants were of the variety Waltham 29. Treatment plots consisted of 2 adjacent 20-plant rows. The treatment plots within a replicate were separated by a single untreated row. Treatments were replicated 4 times.

The effectiveness of the treatments in controlling downy mildew was determined by counting the number of lesions per single leaf per plant, as described previously in the section on influence of insecticides on incidence of downy mildew. Data on mildew control were taken at the time of the main harvest.

Results

1954 Tests: Downy mildew was severe throughout the entire planting. The control of downy mildew provided by the treatments was not sufficient to be considered of practical importance. However, on October 9, the severity of mildew from treatments with Spergon SL, and with the Agrimycin treatment in which 4 sprays were applied, was significantly less than that from the other treatments (Table 3). On October 18, the severity of mildew in plots treated with Spergon SL was significantly less than that in plots treated with other materials. The severity of mildew in plots sprayed with Agrimycin plus the insecticides was greater than that in the Spergon SL plots, but less severe than in plots treated with Dithane D-14 plus zinc sulfate or in plots not treated with a fungicide. Under conditions of this test, Dithane D-14 plus zinc sulfate was ineffective.

Plots sprayed with fungicides alone were heavily infested with cabbage aphids; whereas

plots sprayed with the fungicide-insecticide combination treatments were relatively free from aphids. On the basis of mildew and aphid control, the pesticides in the fungicide-insecticide combination treatments were mutually compatible.

Yields were significantly less from treatments lacking an insecticide than in treatments containing an insecticide.

1955 Test: Agrimycin 100 and Spergon SL were by far the most effective materials for controlling downy mildew in this test (Table 4). Both of these materials reduced the number of lesions significantly below that on plants sprayed with Captan 90W, or with B 622, or that on untreated plants. Although Captan 90W reduced the number of lesions below that on unsprayed plants, the control provided by this material was of no practical significance. The fungicide B 622 was ineffective.

Results from the low gallonage (25 gals./acre) method of spray application were the same as those from the high gallonage (100 gals./acre) method of application. The gallonage and the pressure at which the sprays were applied, therefore, had no influence on the effectiveness of the materials.

Agrimycin 100 sprays caused a slight yellowing of the foliage of the broccoli plants. This yellowing was more severe in plots in which Agrimycin 100 was applied in the high gallonage spray than in the low gallonage spray. The margins of some of the leaves were bleached white. Leaves of some plants sprayed with Spergon SL were slightly chlorotic, and the margins of some had a ruffled appearance. This condition disappeared after spray applications were discontinued.

Control of downy mildew in this test with Agrimycin 100 and Spergon SL was in accord with results of tests conducted in 1954.

DISCUSSION

These studies indicated three probable reasons for the recent increase in downy mildew of broccoli observed in New York State. The first and most important reason appears to be the widespread planting in recent years of the variety Waltham 29, one of the most mildew-susceptible of the medium late varieties of broccoli. The increase in acreage of plantings of the variety Waltham 29 at the expense of varieties such as Calabrese or DeCicco, which are fairly resistant to downy mildew, therefore, can explain much of the recent increase of downy mildew in broccoli plantings. The second reason for the recent increase in downy mildew is the build-up of inoculum as a result of the increase in acreage devoted to broccoli production plus the planting of the mildew-susceptible variety Waltham 29 during successive years. The third reason is the widespread use of emulsifiable insecticide formulations in low gallonage sprays to control insects of broccoli. Foliage of broccoli plants sprayed with emulsifiable insecticide formulations was observed to suffer a loss of bloom and possibly of wax in the cuticle, probably as the result of the dissolving action of the solvent in the insecticide formulation. Leaves so affected were readily wetted and remained wet for a considerable length of time, a condition favoring the germination of mildew spores.

The differences in resistance between broccoli varieties independent of the maturity of the plants indicate that sources of resistance to downy mildew can be found in commercial varieties.

The performance of the fungicides used in these tests may not be indicative of their effectiveness under methods of application in which disease control was the prime objective. Since the object of these investigations was to test the possibilities of controlling downy mildew by incorporating a fungicide with the insecticide spray, the pesticide applications were timed for insect control rather than for downy mildew control. More frequent applications of the fungicides or applications at critical periods during the development of the disease undoubtedly would have resulted in a better performance of the treatments.

Control of downy mildew of broccoli in this test with Agrimycin, and the reported control of downy mildew diseases of other crops with streptomycin, suggest that streptomycin, which was developed primarily for the control of bacteria, may also be effective gainst phycomycetous fungi.

NEW YORK STATE AGRICULTURAL EXPERIMENT STATION, GENEVA

POTATO SEED PIECE TREATMENTS IN PENNSYLVANIA IN 1955

Harry C. Fink, O. D. Burke, R. S. Kirby, and L. P. Nichols[1]

Seven trials were conducted by research and extension men to evaluate potato seed piece treatments under different field conditions. The treatments consisted of a 1-minute dip of streptomycin formulations and fungicides alone and in combination. Streptomycin was used at 100 ppm, Spergon at 1 pound, Phygon at 2 pounds, captan at 1 pound to 20 gallons of water. Nabam was used at 1 pint to 30 gallons and ferbam 10%-streptomycin 1% was used as a dust. The ferbam-streptomycin dust was applied to the freshly cut seed. Since the trials were at different places a chart of results has been prepared that shows in bushels per acre the increase or decrease over the untreated check. These data include only those treatments that were common to two or more of the trials.

Table 1. Results from potato seed treatment trials in Pennyslvania, 1955.

Treatment	Bushels per acre						
Test Number	1	2	3	4	5	6	7
Untreated	214	315	350	399	505	625	173
Seed Piece Treated With	Increase or decrease over untreated						
Streptomycin	+ 59	+ 51		+ 64	+20	+ 93	
Spergon				+ 57	+ 95		
Spergon & Streptomycin				+165			
Phygon	+ 18	+ 58		± 0	+ 20	+ 78	+ 107
Phygon & Streptomycin	+ 60	+ 165	- 52	+54	- 60		
Captan	+46	+ 81	-30	+68	+ 30	+ 85	
Captan & Streptomycin		+ 65					
Nabam		+ 45		+14	- 55		
Ferbam - Streptomycin		+108					+ 54

Stands were usually increased by the treatments. In some cases treatment resulted in more rapid and more vigorous vine growth than untreated. In several cases yields were increased where stands were not increased. Blackleg (Erwinia phytophthora) was not present in sufficient amount to evaluate its control.

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SCREENING OF POTATO FUNGICIDES[1]

L. C. Callbeck[2]

Six fungicides for late blight (Phytophthora infestans) of potato were evaluated in the Screening Plots of the Plant Pathology Laboratory at Charlottetown, Prince Edward Island, in 1955. These fungicides were:

1. Blitox 50. Copper oxychloride, 50% copper.
   Concentration: 4 pounds per 80 Imperial gallons.
   Source: Fisons Pest Control Limited, Cambridge, England, and received through International Fertilizers Limited, Quebec, Que.
2. Captan 50-W
   Concentration: 2-80
   Source: Stauffer Chemical Company through Canadian Industries (1954) Limited, Montreal, Que.
3. Dithane M-22. Maneb.
   Concentration: 1.5-80.
   Source: Rohm & Haas Company through International Fertilizers Limited, Quebec, Que.
4. Perenox. Cuprous oxide, 50% copper.
   Concentration: (a) 4-80 (7 applications)
   (b) 1.5-80 (11 applications)
   Source: Plant Protection Limited, London, England, and received through Canadian Industries (1954) Limited, Montreal, Que.
5. Tennam. Manganese dimethyldithiocarbamate.
   Concentration: 1.5 quarts-80 gallons.
   Source: Tennessee Corporation, College Park, Georgia.
6. Thioneb 50-W. Polyethylene thiuram sulphides.
   Concentration: 1.5-80.
   Source: Naugatuck Chemicals, Elmira, Ontario.

In addition to the above materials, Bordeaux mixture, 8-4-80, was included as a standard treatment.

The plots were planted by hand on June 13, and the seed pieces were counted to assure the same number in each row. The variety Green Mountain was used. Each plot was 4 rows wide by 50 feet long; and 9 plots, one for each treatment, were planted in each of four ranges. All data were taken from the two center rows. A row of potatoes was planted on each side of every plot to buffer the treatments. These rows were not sprayed and served as a source of late blight infection.

Late blight was introduced by disseminating a spore suspension over the buffer rows in the evening of August 5. The weather being favorable for blight development, the disease spread rapidly.

The sprays were applied with an experimental tractor-sprayer unit. The nozzles were so placed on the boom that each potato row received a 4-nozzle spray, and the fungicides were delivered at a pressure of 400 pounds per square inch. The treatments were applied July 20, 29, August 9, 19, 26, and September 2. Perenox at the lower concentration (1.5-80) was applied on these dates, and in addition on July 25, August 3, 13, 30, and September 6. On September 9, the plots for Dithane M-22, Bordeaux, Blitox 50, and Perenox at 4-80 were the only ones treated, the others being severely defoliated by that date.

On September 20, sodium arsenite solution was applied to kill the foliage in those plots that had not been destroyed by disease. The plots were harvested on October 4, and the tubers were weighed, graded, and examined for late blight rot. The results are presented in Tables 1 and 2.

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Table 1. Percentage defoliation caused by late blight.

Treatment	Concentration[a]	Sept. 2	Sept. 9	Sept. 15
Blitox 50	4 - 80	11	35	71
Bordeaux	8 - 4 - 80	10	27	57
Captan 50W	2 - 80	16	63	86
Dithane M-22	1.5 - 80	7	14	27
Perenox (a)[b]	4 - 80	10	42	75
Perenox (b)	1.5 - 80	22	94	100
Tennam	1.5 qt. - 80	37	100	100
Thioneb 50W	1.5 - 80	16	62	84
Check	-	96	100	100

[a] Concentration given in pounds per 80 Imperial gallons except for Tennam which is given in quarts per 80 Imperial gallons.
[b] Perenox (a), 7 applications; Perenox (b), 11 applications.

Table 2. Effect of treatments on yield and on late blight tuber rot.

Treatment	Total bu/ac	Smalls bu/ac	Rot bu/ac	No. 1 bu/ac	% Rot
Blitox 50	277.6	77.5	1.8	198.3	0.7
Bordeaux	304.1	64.6	3.0	236.5	1.0
Captan 50W	276.5	64.6	3.2	208.7	1.2
Dithane M-22	355.2	45.1	3.8	306.3	1.1
Perenox (a)[a]	267.0	70.0	2.0	195.0	0.7
Perenox (b)	219.0	68.3	3.9	147.1	1.8
Tennam	244.9	74.0	10.0	160.9	4.1
Thioneb 50W	295.9	66.3	17.9	211.7	6.0
Check	204.3	86.6	14.8	102.9	7.2
S.D. 5%	22.21			30.08	3.00
S.D. 1%	30.03			40.77	4.08

[a] Perenox (a), 4-80 mixture, 7 applications;
Perenox (b), 1.5-80 mixture, 11 applications.

Dithane M-22 (maneb) was considerably superior to its closest rival, Bordeaux mixture, in both control of disease and production of tubers. The same chemical, under the trade name Manzate, was tested against potato late blight in the 1952 Screening of Potato Fungicides Test at Charlottetown. Among the new materials that were compared in that year it was outstanding. In 1953 and in 1954, maneb's performance was again of a very high order. Of special interest to growers who have followed these tests was its effect on yield. In 1954, for example, maneb-sprayed plots yielded 406.4 bushels per acre, compared to 369.4 for Bordeaux mixture, 362.8 for nabam plus zinc sulphate, and 174.4 for the unsprayed control plots.

The other carbamate (Tennam) tested in 1955 gave very poor results. This fungicide, like Dithane M-22, is a manganese salt, but it belongs to a different group of chemicals. Dithane M-22 (manganese ethylene bisdithiocarbamate) is a member of the ethylene group whereas Tennam (manganese dimethyl dithiocarbamate) is a member of the dimethyl group of carbamate fungicides. In these annual tests, carbamate fungicides of the dimethyl type have consistently been inferior to carbamate fungicides of the ethylene type, even though the metallic part -- zinc, manganese -- of the molecules be the same. The results in 1955 with Tennam are therefore in accord with those obtained in previous tests with related compounds.

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TREATMENT OF VEGETABLE SEED FOR IMPROVED EMERGENCE -- 1955[1]

V. R. Wallen and W. Bell[2]

Previous work (1, 2, 3) has demonstrated that certain seed treatments can bring about a significant increase in emergence from aged vegetable seed and seed of low germination.

In 1955 a similar trial was made except that most of the seed was only 1 year old and had a fairly high germination (Table 1). Twenty-four kinds of vegetable seeds were used this year and the seed was treated with seven fungicides and one antibiotic. Three fungicides used last year were included this year, namely, Phygon, Orthocide 75, and Merculine; the last-named was applied at 1 oz. per 100 lb. of seed, instead of at 2 oz. per 100 lb. as in last year's trial. Thioneb 50W, Agrox C, Spergon, and Captan 50W were also included in this year's trial. Captan 50W, although not recommended as a seed treatment, was used for comparative purposes. The seed was treated as previously (3), using 2-oz. samples for small seeded vegetables and up to 1 lb. samples for the larger seeded kinds. The treated seeds were stored at room temperature in stoppered flasks at 65° to 75° F for 2 to 3 weeks before being sown in the field. Each treatment was replicated and randomized four times and emergence counts were started 2 weeks after planting.

The dosages of each fungicide for each kind of vegetable seed are as follows:

Agrox C (phenyl mercury acetate 7.06%, ethyl mercury chloride 1.06%):

Thioneb 50W (ethylene thiuram sulphides 50%):

Captan 50W (captan 50%):

Phygon (2, 3-dichloro-1, 4 naphthoquinone 98%):
1 1/2 oz. per 100 lb. for soybeans, and corn; 2 oz. per 100 lb. for peas, bush beans, and lima beans; 3 oz. per 100 lb. for muskmelon; 4 oz. per 100 lb. for asparagus, cabbage, cucumber, onion, pumpkin, radish, spinach, squash, cauliflower, swiss chard, vegetable marrow, watermelon, swede, brussels sprouts, and broccoli; 8 oz. per 100 lb. for carrot, beet, and dill.

Merculine (emulgate of 10% phenyl mercury salicylate):
1 fl. oz. per 100 lb. of seed for all vegetables.

Spergon (chloranil 97%):
3 oz. per 100 lb. for garden beans, lima beans, soybeans, corn, and peas; 6 oz. per 100 lb. for cucumber, muskmelon, pumpkin, squash, vegetable marrow, and watermelon; 8 oz. per 100 lb. for asparagus, broccoli, brussels sprouts, cauliflower, cabbage, onion, radish, spinach, swede, and swiss chard; 12 oz. per 100 lb. for carrot and dill; 16 oz. per 100 lb. for beet.

Orthocide 75 (captan 75%):
3/4 oz. per 100 lb. for corn; 1 1/2 oz. per 100 lb. for garden beans, lima beans, peas, soybeans, swede, swiss chard, cabbage, cauliflower, brussels sprouts, and broccoli; 2 oz. per 100 lb. for vegetable marrow, watermelon, squash and pumpkin; 3 oz. per 100 lb. for cucumber and muskmelon; 6 oz. per 100 lb. for asparagus, carrot, onion, spinach, dill, and radish; 12 oz. per 100 lb. for beet and swiss chard.

Results summarized in Table 2 show several interesting facts. When compared with the results of the past 2 years (2, 3) it is evident that asparagus seed has not responded to seed treatment. Carrot and radish seed responded by an increased emergence in 2 out of 4 years of

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[2] Plant Pathologist and Technician respectively.

Table 1. List of vegetables used in seed treatment test, their varietal names, the year of harvest of the seed, and the percentage germination of this seed in 1955.

Kind	Variety	Percent germination 1955	Year of harvest
Asparagus	Eden	96	1953
Bush Bean	Bountiful	85	1948
Lima Bean	Fordhook Bush	72	1954
Soybean	Blackeye	92	1951
Beet	Detroit Dark Red	66	1944
Broccoli	De-Cicco	77	1954
Brussels Sprouts	Early Morn	58	1954
Carrot	Gold Spike	94	1954
Cauliflower	Stokes Super Snowball	82	1954
Cabbage	Chieftain Savoy	61	1954
Corn	Banting	83	1954
Cucumber	Straight Eight	85	1954
Dill	Mammoth	69	1954
Muskmelon	Farnorth	88	1952
Onion	Brigham Yellow Globe	90	1953
Peas	Selkirk	94	1952
Pumpkin	Small Sugar	78	1954
Radish	Comet	46	1954
Spinach	Bloomsdale L.S.	44	1954
Squash	Warted Hubbard	99	1954
Swede	Laurentian	99	1954
Swiss chard	Lucullus	86	1949
Vegetable marrow	Vegetable Marrow Bush	90	1954
Watermelon	Early Canada	95	1954

Table 2. Mean percentage field emergence from vegetable seed treated with various seed dressings, based on four samples of 100 seeds each.

Kind of seed	Untreated	Agrox C	Captan 50W	Merculine	Orthocide 75	Phygon	Spergon	Thioneb 50W	Filipin	L.S.D.[a]
Asparagus	90.5	88.5	75.5	84.0	75.5	62.75	86.75	76.25	85	....[b]
Bush Bean	90.75	68.75	90.0	91.75	89.75	93.75	90.00	90.5	90.5	....[b]
Lima Bean	69.0	68.75	82.5[d]	78.0	78.75	79.25	79.75	76.75	73.0	5.88
Soybean	16	50.75	60.5	56.0	57.75	40.5	51.25	53.75	10.0	5.15
Beet	95.75	144.25	122.5	77.75	121.25	131.0	53.5	95.25	50.5	12.58
Broccoli	45.0	47.75	56.0	45.25	52.25	51.0	52.0	55.0	45.75	6.41
Brussel Sprouts	26.75	31.5	39.75	32.5	42.5	35.75	28.5	33.2	27.5	5.83
Carrot	39.0	22.75	26.5	30.5	31.75	30.75	33.5	27.75	37.5	....[b]
Cauliflower	32.75	33.75	35.5	37.0	31.0	28.0	35.5	33.25	29.25	....[b]
Cabbage	23.5	37.5	35.5	37.0	31.0	28.0	27.0	32.25	29.0	5.4
Corn	62.5	70.5	76.0	69.0	67.0	67.0	78.25	69.25	68.0	5.73
Cucumber	46.5	60.75	60.0	65.0	60.5	67.5	60.75	62.25	60.25	9.7
Dill	42.75	37.5	38.5	45.75	39.75	42.5	35.75	39.75	40.75	....[b]
Muskmelon	41.75	52.5	68.25	58.75	69.5	59.5	52.0	52.5	54.25	5.97
Onion	45.25	51.75	51.5	52.5	51.5	52.25	45.75	48.75	48.0	6.27
Peas	82.25	94.75	92.75	93.75	94.5	96.25	96.25	90.5	76.25	3.09
Pumpkin	34.25	57.5	52.75	54.0	58.25	56.0	53.5	44.75	33.75	5.3
Radish	37.75	47.0	44.0	44.25	49.25	44.25	40.0	37.75	34.25	4.77
Spinach	18.5	21.25	17.5	17.25	27.0	20.25	19.5	22.5	19.75	....[b]
Squash	48.5	86.0	86.75	86.25	86.5	87.75	73.5	81.75	.....[c]	6.72
Swede	67.75	75.0	77.25	68.5	70.0	81.25	75.0	75.5	70.5	6.08
Swiss chard	65.75	180.5	185.75	136.25	193.25	171.75	78.25	152.25	45.25	19.99
Vegetable marrow	38.0	62.0	57.0	60.75	66.25	57.5	55.75	54.75	35.75	8.43
Watermelon	32.75	62.25	59.75	47.5	59.0	61.75	57.25	67.75	47.0	10.24

[a] L.S.D. at the 5% level

[b] No significant increase between treatments

[c] Not attempted

[d] Underlined numbers indicate significant increase in emergence

testing, while cabbage, corn, dill, onion, and spinach responded in all but one year. Soybeans, peas, beet, swiss chard, cucumber, pumpkin, squash, and vegetable marrow responded to seed treatment in all years under test.

Of the 24 vegetable seed stocks under test in this year's trial, 18 responded to treatment with at least one of the seed treatments. If the antibiotic, Filipin, is omitted, the seeds of soybeans, peas, and all five cucurbits germinated significantly better when treated with any of the seven chemical treatments than when left untreated. Of these seven treatments Captan 50W appears to be the best general seed treatment; it gave a significant response with more kinds of seed than any other treatment tested, and more often the response obtained with it was slightly better in some cases than that with other seed treatments tested, although the differences were not statistically significant. Phygon and Spergon were the best for peas, and the results with the organic mercurial, Agrox C, suggest that such preparations may be preferred for treating beet and swiss chard seed.

Although Captan 50W improved the emergence in 17 vegetables as against 15 for Orthocide 75, in most cases, except for swede and corn, these two fungicides appeared to be equally beneficial for those crops.

The antibiotic Filipin was used at the maximum retaining capacity of the seed. This concentration was purely experimental and more work on the correct dosage for the various vegetable seeds must be done before a correct assessment can be made of the value of this antibiotic. In this trial three vegetable crops benefitted from this dosage, namely, cucumber, vegetable marrow, and muskmelon. At the concentration used, Filipin was phytotoxic to beet seed possibly because of the high retaining capacity of this seed.

The authors wish to express their appreciation to Miss Angela Wallace and Mr. Peter Sherwood for technical assistance with this problem.

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A SUMMARY OF RESISTANCE AND SUSCEPTIBILITY TO PUCCINIA ASPARAGI DC. WITHIN THE GENUS ASPARAGUS

A. E. Thompson and P. R. Hepler[1]

Summary

With improved inoculation techniques it has proved possible to demonstrate a degree of susceptibility in some of the perfect flower species of asparagus previously reported to be resistant to or immune from Puccinia asparagi DC. Small numbers of uredial pustules were observed after inoculation with urediospores on certain accessions of the following: Asparagus plumosus var. nanus (Baker) Hort., A. plumosus var. pyramidalis (Baker)?, A. plumosus var. robustus (Baker) Hort., A. sprengeri var. robustus (Regel)?, A. virgatus Baker, and a dwarf Chinese species (PI 23016). Two perfect flowered species, A. rivalis Burch. and A. laricinus Burch., have not as yet been infected following repeated inoculations. The dioecious species A. filicinus Ham. appears to be as highly susceptible as the cultivated species A. officinalis L. None of the dioecious species tested have a higher level of resistance than A. officinalis L. The perfect-flowered species have a higher level of resistance than the dioecious species, but most of those tested can not be considered immune.

In the course of investigations on methods of breeding for resistance to asparagus rust an attempt was made to collect all available species of the genus Asparagus. These species have been subjected to inoculations with urediospores of Puccinia asparagi DC. on numerous occasions. It was thought desirable to summarize the literature on the subject and concurrently present the most recent results of rust resistance and susceptibility in asparagus species.

Reports of some of the recent tests made at the Illinois Agricultural Experiment Station have been published previously by Kahn, et al. (9), Beraha (3, 4), and Hepler (8). Most reports in the literature refer to resistance or susceptibility to uredial infection. Beraha (3) reported successful infection resulting in production of all four spore stages of the fungus on A. acutifolius L., A. maritimus Mill., and A. scaber Brig., in addition to A. officinalis L.

The methods used for inoculation were those devised by Kahn, et al.(9) and refined by Beraha (3). The intensity of rust infection was measured by counting the number of primary pustules per plant.

Baker's taxomonic classification of the genus Asparagus (1, 2) was taken as the authority on nomenclature of the species and type of flowering. The Index Kewensis and the Index Londinensis and their supplements were also checked. Those species where the name and authority could not be verified are followed with a question mark.

Table 1 presents a summary of a test of asparagus species and varieties made in 1952. A marked difference in resistance is shown if a comparison is made between the perfect-flowered species and the dioecious species. These results confirm those previously reported by Kahn, et al. (9) and Beraha (3). The so-called "resistant" varieties of the cultivated species of asparagus appear to be more resistant than the other three dioecious species. The susceptibility of the latter three dioecious species appears to be intermediate or as high as the highly susceptible varieties of A. officinalis. The difference between the resistant and the highly susceptible varieties of A. officinalis has been shown by Hepler (8) to be consistent and heritable.

Table 2 presents a summary of the literature on the resistance and susceptibility of asparagus species. The species are grouped on the basis of flower type. Those species that have University of Illinois accession numbers recorded have been tested for resistance during the current investigation. The column listed as relative resistance places the species on a scale relative to the degree of resistance found in A. officinalis. The highly susceptible varieties or strains are rated as 5 while the so-called resistant varieties have a value of 3. Those species with a 0 rating have never been observed to show any symptoms of rust infection and may be termed immune. Species given a rating of 1 are those that were infected with difficulty but did form sporulating uredial pustules.

The reaction of four species to asparagus rust is reported for the first time. A. filicinus Ham., a dioecious species, was found to be as susceptible as most of the cultivated varieties

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Table 1. A comparison of resistance of four dioecious and four perfect-flowered asparagus species to asparagus rust (Test 52-1).

Species	Flower type	Number of plants tested	Percentage of infected plants	Mean number pustules/plant
A. acutifolius L.	Dioecious	33	90.91	9.94 ± 1.95
A. maritimus Mill.	"	26	76.92	11.15 ± 2.95
A. officinalis L. ("resistant" vars.)[a]	"	3,435	84.22	4.76 ± 0.11
A. officinalis L. (susceptible vars.)[b]	"	360	96.67	19.29 ± 1.20
A. scaber Brig.	"	49	91.84	20.47 ± 3.35
A. asparagoides Wight	Perfect	44	0	0
A. plumosus var. nanus (Baker) Hort.	"	55	0	0
A. scandens var. deflexus (Thunb.) Baker	"	4	0	0
A. sprengeri Regel	"	53	0	0

a. Argenteuil, Calif. 500, Mary Washington, Paradise and Viking

b. Conover's Collosal, Mammoth Emperor and Snowhead

Table 2. A summary of resistance and susceptibility of asparagus species to rust as experimentally determined and previously reported in the literature.

U. of Ill. accession number	Species	Flower type	Rust reaction as reported by[b]: Resistant	Susceptible	Relative resistance[a]
75,114	A. acutifolius L.	Dioecious		3,4	5
---	A. brachyphyllus Turcz.	"		5	-
---	A. caspius Hoh.	"		6	-
85	A. filicinus Ham.	"			3
68	A. maritimus Mill.	"		3,4,5,6	5
(85 accs.)	A. officinalis L.	"		3,4,5,6,7,8, 9,10,11,12	3-5
77	A. psuedoscaber Grecescu	"		10	5
69	A. scaber Brig.	"		3,4	5
---	A. scaberoides?	"		5	-
78	A. verticillatus L.	"		6,11,12	4
74,106	A. asparagoides Wight	Perfect	3		0
---	A. decumbens Jacq.	"	7		0
79	A. laricinus Burch.	"			-
---	A. plumosus Baker	"	6,7		1
71	A. plumosus var. nanus (Baker) Hort.	"	3,7,9	12	0
113	A. plumosus var. nanus (Baker) Hort.	"	3,7,9	12	1
105	A. plumosus var. pyramidalis (Baker)?	"			1
104	A. plumosus var. robustus (Baker) Hort.	"			0
80	A. rivalis Burch.	"	6		-
---	A. scandens Thunb.	"	3,9		0
73	A. scandens var. deflexus (Thunb.) Baker	"	3,7,9		0
72,101,111	A. sprengeri Regel	"			1
102	A. sprengeri var. robustus (Regel)?	"	7		-
---	A. tenuissimus Hort.	"	9,10		2
70	A. virgatus Baker	"	9,10		
109	A. virgatus Baker			12	-
---	A. broussonettii Jacq.	Unknown	7		1
---	A. pitcherianus?	"			
115	Dwarf Chinese spp. (PI 23016)				

[a] A relative scale, 5 = highly susceptible, 0 = immune (no uredial pustules observed).

[b] Figures refer to Literature Cited.

of A. officinalis. Two perfect-flowered species, A. laricinus Burch. and A. rivalis Burch., have not been infected to date. The species A. rivalis is considered by Baker (1, 2) to be synonomus with A. asiaticus L. No report of resistance of the latter species has been found in the literature. A dwarf Chinese species (PI 23016) has been found recently to be slightly susceptible following repeated inoculations. Flowering has never been observed in this species, but plant characteristics lead one to suspect that it would be perfect-flowered.

With improved inoculation techniques it has been possible to demonstrate a degree of susceptibility in some of the perfect-flowered species previously reported to be resistant or immune. The three botanical varieties of the species A. plumosus Baker proved to be slightly susceptible to asparagus rust. Some variability may exist within A. plumosus var. nanus (Baker) Hort., as only one of the two accessions has proved susceptible to date. A. plumosus var. nanus had been reported to be susceptible to uredial infection by Sheldon (12), but his finding had not been previously confirmed. Three accessions of A. sprengeri Regel have not been infected, but A. sprengeri var. robustus (Regel)? proved to be slightly susceptible. One accession of A. virgatus Baker has not been infected, but another showed a degree of susceptibility that is slightly less than that found in resistant varieties of A. officinalis.

It should be emphasized that the level of resistance of the perfect-flowered species is considered to be high even in those species where a low level of infection has been observed. A large difference in the reaction to the rust pathogen is apparent when the perfect-flowered species are compared with the dioecious species. None of the dioecious species tested appear to have a higher level of resistance than that present in the resistant varieties of A. officinalis. Although the number of species tested is only a small proportion of those classified, the current results suggest that immunity from rust may not be found in the genus Asparagus. With refined techniques it may be possible to infect all species of the genus.

Attempts have been made to transfer the high level of resistance from some of the perfect-flowered species to A. officinalis, but to date no successful crosses have resulted. The perfect-flowered species are widely divergent in plant characteristics. It is doubtful if anything of olericultural value could be obtained even if fertile hybrids should be derived from crosses between A. officinalis and the perfect-flowered species. Little improvement in rust resistance can be expected in progenies of crosses among dioecious species. Currence (5) reported that successful crosses have been made between A. officinalis and the three species A. brachyphyllus Turcz., A. maritimus, and A. scaberoides? He further reports that the species as well as their hybrids were susceptible to rust in the very wet year of 1951.

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UNIVERSITY OF ILLINOIS

SORGHUM SEED-TREATMENT TESTS IN 1955

R. W. Leukel[1], R. H. Porter[2] and O. J. Webster[1]

Covered kernel smut in Leoti sorgo was controlled satisfactorily in 1948, 1949, 1950 and 1953[3] by certain mercurial fungicides and by some non-mercurials like Phygon. (Table 1). The seeds of Leoti have persistent glumes, which characteristic makes smut control more difficult in this and similar varieties than in most kafirs, the seeds of which lose their glumes in threshing.

In 1954 a quantity of Rancher sorgo seed from Brookings, South Dakota, was kindly supplied by C. J. Franzke. The seeds of this variety also have persistent glumes, but Rancher seemed preferable to Leoti for field tests because it matures earlier, is much shorter and is less apt to lodge.

However, in the 1954 tests with this variety smut control with a mercurial disinfectant was less satisfactory than in the previous tests with Leoti (Table 1). Therefore, in 1955, to

Table 1. Summary of infection by covered kernel smut in plants grown from treated and untreated seed of Leoti sorgo and of Rancher sorgo in the years indicated.

Seed treatment			Percent smut infection				
			Leoti				Rancher
Fungicide	Form	Oz/bu	1948	1949	1950	1953	1954
Ceresan M	Slurry	1/2	0.1	0	0	0	—
Panogen	Liquid	3/4	0	0	0	0	2.1
Phygon	Slurry	2	0.6	0.9	0	0	0.1
Arasan	Slurry	2	6.1	1.9	0	0	3.7
Spergon	Slurry	2	1.2	1.8	0	—	3.1
Orthocide	Slurry	2	—	—	—	0.9	5.0
Check			51.1	46.0	33.5	60.5	30.9

determine whether heavier applications of fungicides are necessary to control smut in Rancher and possibly in other sorgos, it was planned to apply five mercurials to infested seed of this variety at the generally recommended rates and at 1 1/2 and 3 times those rates. Panogen and three non-mercurials were to be applied at the usual rates and at 1 1/2 and 2 times those rates.

To determine the possible effects of higher rates of treatment on the viability of sorghum seed, Sharon kafir seed was first treated as suggested above, and three lots of 100 seeds each from each treatment were planted in pans of non-sterilized soil 5 days after treatment. The pans were kept at 25° C until after emergence of the seedlings. At the same time several seeds from each treated lot were placed on small plates of water agar, rolled about gently to remove some of the spores, and then discarded. The plates were kept at 25° C for several days and examined periodically for spore germination. The results along with seed germination data are shown in Table 2.

Only three of the fungicides applied at the heavier rates seemed to depress appreciably emergence from treated seed. Five mercurials failed to inhibit spore germination completely at the lightest rate of fungicide applications, two at the medium rate, and one at the heaviest

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[3] See Plant Dis. Reptr. Vol. 33: 39-41 and 378-380; Vol. 34: 342-343; Vol 35: 451-452; and Vol. 37: 585-586.

Table 2. Emergence from kafir seed, variety Sharon, treated with fungicides, (a) at the standard rate (b) and (c) at 2 and 3 times the standard rate for the mercurials, and 1.5 and 2 times for the non-mercurials; also germination of smut spores taken from the different lots of seed, 1955.

Seed treatment					Percent emergence			Percent spore germination		
		Oz. per bu.								
No.	Fungicide	a	b	c	a	b	c	a	b	c
1	Check				83	79	76	95	75	70
2	Ceresan M	0.5	1	1.5	84	80	88	0	0	0
3	Puraseed	0.5	1	1.5	93	86	89	2	0	0
4	MEMA	0.5	1	1.5	91	61	52	15	15	3
5	Panogen	0.75	1.5	2.25	93	66	63	25	2	0
6	Merculine	0.5	1	1.5	94	88	79	17	0	0
7	Setrete	0.5	1	1.5	91	91	86	31	0	0
8	Phygon	2	3	4	95	92	95	0	0	0
9	Orthocide	2	3	4	91	92	90	0	0	0
10	Arasan	2	3	4	92	91	91	0	0	0

Table 3. Percent emergence and infection covered kernel smut in Rancher sorgo grown from seed untreated or treated as shown, planted in field plots in triplicate at three stations, 1955.

Seed treatment				Percent emergence		Percent smut			
No.	Fungicide	Form	Oz/bu	Fort Collins	Lincoln	Fort Collins	Lincoln	Belts-ville	Aver-age
1	Check			57	78	20.4	30.1	42.1	30.9
				59	79	15.8	24.5	44.9	28.4
				66	83	17.7	19.8	41.7	26.4
2	Ceresan M	Slurry	0.5	59	77	5.7	8.9	10.5	8.4
			0.75	50	80	1.5	10.0	12.6	8.0
			1.5	68	76	1.2	9.5	8.1	6.3
3	Puraseed	Slurry	0.5	61	86	7.6	20.3	33.3	20.4
			0.75	56	73	3.4	19.2	38.0	20.2
			1.5	52	81	4.5	25.1	24.1	17.9
4	MEMA	Liquid	0.5	51	66	18.6	41.9	42.9	34.5
			0.75	53	74	9.8	23.6	33.2	22.2
			1.5	53	80	3.7	21.2	26.7	17.2
5	Panogen	Liquid	0.75	57	81	20.9	38.8	36.3	32.0
			1.12	57	81	11.2	23.0	30.7	21.6
			1.5	70	84	8.2	23.0	27.7	19.6
6	Merculine	Liquid	0.5	58	82	18.6	25.5	34.7	26.3
			0.75	56	82	14.8	25.2	27.1	22.4
			1.5	71	81	5.3	18.8	21.7	15.3
7	Setrete	Liquid	0.5	57	79	16.1	24.1	35.2	25.1
			0.75	54	80	10.8	26.7	33.3	23.6
			1.5	57	78	9.1	16.2	25.2	16.8
8	Phygon	Slurry	2	55	76	0.5	4.9	4.5	3.3
			3	48	74	0	0	3.0	1.0
			4	65	81	0	0	1.6	0.5
9	Orthocide	Slurry	2	61	81	20.5	25.3	32.9	26.2
			3	56	81	0.5	7.3	12.8	6.9
			4	65	77	0.2	0	0.8	0.3
10	Arasan	Slurry	2	55	81	18.5	29.9	39.1	29.2
			3	66	83	3.3	6.6	14.8	9.2
			4	69	83	0.2	7.1	10.6	6.0

rate.

Rancher seed was treated approximately as described above (Table 3) and, along with untreated seed, was planted in triplicate at three locations -- Fort Collins, Colorado, Lincoln, Nebraska, and Beltsville, Maryland -- at the rate of 200 seeds per row. Stand counts were made at Fort Collins and Lincoln, but were valueless at Beltsville because of heavy rains and soil washing.

In taking data on smut infection[4] and control, the total heads and the smut-infected heads in each row were counted. These data along with the field data on emergence at Lincoln and Fort Collins are shown in Table 3.

For testing smut control in a variety without persistent glumes, Combine-60 kafir was used in 1955 instead of Sharon kafir because of its earlier maturity. A supply of this seed was obtained from Dr. N. W. Kramer, Lubbock, Texas. It was inoculated with spores of covered-kernel smut at a 1 to 250 spore dosage, and was to be treated at the low and medium rates used on Rancher. The nine fungicides were applied first to separate lots of seed at the lower rates (3/4 oz./bu. for Panogen, 1/2 oz.bu. for the other five mercurials and 2 oz./bu. for the three non-mercurials). The second series of samples were to be treated at 1 1/2 times those rates. Through the operator's error, the first series of samples was treated also with the second application, while the second series of samples received no treatment. The error was not discovered until the data on smut infection were taken. The complete lack of any apparent smut control in one series led to an examination of the seed remnants. The presence of seed-infesting insects in these remnants indicated lack of treatment. The data taken on the plants from treated seed along with the infection data from untreated seed are shown in Table 4.

Table 4. Emergence and smut-control in Combine-60 kafir, grown from untreated and from treated seed, planted in triplicate rows at each of three stations, 1955.

Seed treatment				Percent field emergence		Percent infected heads			
No.	Fungicide	Form	Oz/bu	Fort Collins	Lincoln	Fort Collins	Lincoln	Beltsville	Average
1	Check			61	80	28.2	36.9	60.3	41.6
2	Ceresan M	Slurry	1 1/4	50	80	0	0	0	0
3	Puraseed	Slurry	1 1/4	56	73	0.9	0.5	0.5	0.6
4	MEMA	Liquid	1 1/4	53	74	0	0	0.4	0.1
5	Panogen	Liquid	1 7/8	57	81	0	0	0	0
6	Merculine	Liquid	1 1/4	56	82	0.6	2.0	0	0.3
7	Setrete	Liquid	1 1/4	54	80	0	0	0	0
8	Phygon	Slurry	5	48	74	0	0.5	0	0.2
9	Orthocide	Slurry	5	56	81	0.9	4.1	0.9	2.0
10	Arasan	Slurry	5	66	83	1.2	0	1.6	0.9

Discussion

The superiority of Phygon compared with mercurials and with other non-mercurials in controlling covered kernel smut in Rancher sorgo, especially with the heavier applications, seems to make it the logical choice as a seed disinfectant for sorghum seed with persistent glumes.

AGRICULTURAL RESEARCH SERVICE, FIELD CROPS RESEARCH BRANCH, UNITED STATES DEPARTMENT OF AGRICULTURE, IN COOPERATION WITH THE STATE EXPERIMENT STATIONS AT LINCOLN, NEBRASKA AND FORT COLLINS, COLORADO

[4] R. H. Porter, Plant Dis. Reptr. 39: 688-689. Sept. 15, 1955.

RHIZOPUS ORYZAE WENT ET GEERLIGS ASSOCIATED WITH INJURY TO SORGHUM SEED[1]

R. H. Porter

In the spring of 1955 a sample of Ellis sorghum seed was received from the Colorado Seed Laboratory for pathological examination. The sample was from the 1954 crop. The test made in the seed laboratory showed low germination except when treated with Arasan, which gave a marked increase in number of normal seedlings.

The sample of seed was divided into four sub-samples and labeled 1, 2, 3, and 4. No. 1 was retained as a check and the other 3 were treated respectively with Arasan [bis (dimethylthiocarbamyl) disulfide] , Ceresan M [N-(ethylmercuri)-p-toluenesulfonanilide] , 1 part to 4 parts of talc, and Phygon (2, 3-dichloro-1, 4-naphthoquinone) each at the rate of 50 mg of dust to 20 g of seed per row. There were 5 replications in a randomized block design. When the seedlings were about 2 to 3 in. tall, a field germination count was made.

A second planting was made in the greenhouse using 2 lots of 100-seeds in steamed sand in benches. When the seedlings were 4 in. tall, they were pulled from each row and counted, and the primary root and epicotyl of each seedling were examined for lesions. Those which showed a definite shrunken condition were classed as diseased.

A third test was made in the laboratory using germination dishes with filter paper as the substrate. From each sub-sample, 100 seeds were planted and after 8 to 10 days counts were made for total normal and total weak sprouts as well as number of seeds or seedlings partially or completely covered with molds.

The results of the 3 tests are summarized in Table 1.

Table 1. Field, greenhouse, and laboratory germination of treated and non-treated seed of Ellis sorghum. Fort Collins, 1955.

Treatment	Mean number seedlings per field row	Emerged	Number diseased	Normal	Weak	Number moldy
		%		%	%	
Check	79.3	20.5	6	33	49	100
Arasan	188.0	89	8	94	2	1
Ceresan M	116.7	44	27	59	35	100
Phygon	195.7	86	1	92	4	1

These tests have been of particular interest because with no other lots of sorghum have such marked differences in germination of treated and non-treated seed been obtained during the past 3 years. It is noteworthy that seed treated with Arasan or Phygon gave more than twice as many seedlings in the field test as did non-treated seed. Increases in germination in greenhouse sand were even greater.

It was assumed in the beginning of the trials that some highly pathogenic seed-borne organism was involved. At the close of the laboratory test the molds were examined and the predominant one associated with the injury was Rhizopus oryzae Went et Geerligs. After a few days it formed a complete mat over the seeds. A few seedlings were covered with either Aspergillus niger Van Tiegh. or Penicillium variabile Sopp. Identification of the organisms was made by Dr. L. W. Durrell.

BOTANY AND PLANT PATHOLOGY SECTION, COLORADO AGRICULTURAL EXPERIMENT STATION, FORT COLLINS, COLORADO

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OCCURRENCE OF BARLEY STRIPE MOSAIC IN MONTANA[1]

M. M. Afanasiev[2]

Barley stripe mosaic, a new virus disease of barley, was identified in 1950 (2). This disease was known since 1910 as false stripe of barley and considered to be a physiological disease of barley. Experiments conducted in Montana showed that this disease can cause serious reduction in yield in several varieties of barley (1).

The symptoms of this mosaic usually manifest themselves in the form of chlorotic mottling, spotting, and streaking. The chlorotic areas in the leaves often become ashy-gray. Brown stripes also occur in the leaves. The virus is seed-borne and can easily be transmitted by manual inoculation. This virus infects barley, wheat and some grasses.

During the winter and spring of 1954-55, a survey was conducted to find out the amount of barley stripe mosaic present in barleys grown in Montana. A total of 231 lots of barley was tested in the greenhouse for this disease. The majority of these samples (219) were Compana. A small number of other varieties as Titan, Gem, Vantage, Moore, and Moravian were also examined for this disease. These varieties of barley are not important at the present time in Montana since at least 90 percent of the barley acreage is planted to Compana barley.

The tests were conducted in the greenhouse where one flat of soil 20 x 12 x 3 inches was planted with 100 barley seeds per each sample. The first reading was made when the plants developed about three leaves and the second reading about 10 days later. Final results were based on the second reading. The duration of this test was about three weeks in the winter and two weeks in the spring. Out of 219 samples of Compana barley, 99 lots were free of this disease (45.2%) and 120 lots (54.8%) were infected in various degrees. Among 120 infected lots, 59 lots (26.9%) showed seed infection up to 5 percent; 25 lots (11.4%) from 5 to 10 percent; 29 lots (13.2%) from 10 to 25 percent; and 7 lots (3.3%) from 25 to 50 percent.

The average of the disease for all samples of infected Compana barley tested (120) was 9.2 percent.

It is recommended to plant only those lots of barley which are free of barley stripe mosaic.

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MONTANA AGRICULTURAL EXPERIMENT STATION, BOZEMAN

[1] Contribution from Montana State College, Agricultural Experiment Station, Bozeman, Montana. Paper No. 369 Journal Series.

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TRANSMISSION EXPERIMENTS AND XYLOPOROSIS-CACHEXIA RELATIONS IN FLORIDA

J. F. L. Childs[1]

INTRODUCTION

The purpose of this paper is to bring up to date certain information on bud transmission of cachexia, to show the relation of cachexia to xyloporosis as known in Florida and to report some preliminary evidence of seed transmission of the causal agent of xyloporosis.

Cachexia was described on Orlando tangelo (C. paradisi x C. reticulata) in 1950 (1). Experiments on its bud transmission and perpetuation were reported and the striking resemblance to xyloporosis of sweet lime (C. aurantifolia) as described in Palestine (9) was discussed (2). More recently it was reported that cachexia is very widely distributed in the citrus varieties formerly and presently grown in Florida and that a very high proportion of the commercial citrus varieties are infected (3, 6).

Symptoms of xyloporosis on sweet lime rootstocks in Florida were reported (4) in 1951. Identification of xyloporosis in Florida was based on the similarity of its symptoms to those of xyloporosis in South America (4). According to Moreira (7, 5) identification of xyloporosis in South America was based on the similarity of its symptoms to those of the Palestine disease. No cross-inoculations were made in either case.

The relation between cachexia of Orlando tangelo and xyloporosis of sweet lime in Palestine will not be definitely settled until cross-inoculation studies of the Orlando tangelo and the Palestine form of xyloporosis are made. However, examination of information bearing on this relation is desirable at this time in view of the wide distribution of xyloporosis (cachexia) in Florida (3, 6) and its importance.

It has been observed that certain symptoms of the two diseases are not identical, e.g., that phloem discoloration, which is characteristically pronounced in cachexia-affected Orlando tangelo trees, is not present or is at least much less marked in xyloporosis-affected sweet lime. Also, wood pitting characteristics of xyloporosis has been reported on unbudded seedling sweet lime trees in Palestine, but not on unbudded Orlando tangelo seedlings.

Differences in the degree of symptom expression such as phloem discoloration may be the result of differences in varietal response. For example, gum impregnation of the phloem tissues is pronounced in Orlando tangelo, weak in Williams tangelo, and apparently absent in Watt and Webber tangelos infected with the causal agent of cachexia. Varietal differences in symptom expression are also indicated by Olson's observation (8) that symptoms are slower to develop (by two years) in Satsuma mandarin (C. reticulata) than in Orlando tangelo. It is of interest that Nocatee tangelo trees, seen by the author in Israel and said to be affected with xyloporosis, exhibited phloem discoloration as pronounced as that exhibited by cachexia-affected Orlando tangelo trees in Florida. Xyloporosis symptoms in unbudded sweet lime seedlings are discussed later in the paper under seed transmission.

In this paper the author uses the term "cachexia" in reference to the Orlando tangelo disease and the term "xyloporosis" in reference to the sweet lime disease, but considers them to be caused by the same virus, or strains of the same virus.

TRANSMISSION EXPERIMENTS

Bud transmission of cachexia: In a previous experiment 3 lots of scions (21, 16, and 17 respectively) from cachexia-infected parent Orlando tangelo trees expressed symptoms in 95.3, 86.7, and 94.2 percent of trees 4 years after budding on Rough lemon (C. limon) rootstock (2). In 5 years symptom expression of these 3 lots was 100 percent. In contrast, lots (21, 24, and 21 trees, respectively) budded from cachexia-free trees were 100 percent free of symptoms.

In further recently completed experiments on the bud transmission of cachexia fifteen cachexia-infected Orlando tangelo buds, each from a different tree, were inserted in Orlando tangelo seedlings. Because of the unfavorable weather conditions, all the buds died shortly (1 to 8 weeks) after insertion, but 4 years later 13 of the 15 seedlings expressed bark symptoms of cachexia. At the time 15 cachexia-free buds, each from a different tree, were similarly inserted in Orlando seedlings, and subsequently these buds also died. None of the latter trees

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developed cachexia symptoms within the 4-year observation period.

In another experiment, single buds from each of five different cachexia-infected Orlando tangelo trees were inserted in five Orlando tangelo seedlings. Subsequently all buds died, but within a 4-year period the five Orlando tangelo seedlings developed bark symptoms of cachexia. Five unbudded seedlings of the same lot developed no symptoms within the same period. Thus as a result of past and recent experience, it seems safe to assume that Orlando tangelo seedlings will develop cachexia symptoms within 2 to 5 years, if cachexia virus is present.

Bud transmission of Florida xyloporosis: Buds from two Hamlin orange (C. sinensis) trees and five Temple orange (C. sinensis x C. reticulata) trees on Florida sweet lime rootstocks affected with xyloporosis were propagated on seven Orlando tangelo seedlings. Subsequently six of the buds died, but the rootstock with the living bud, as well as three of the stocks on which the buds died, developed bark symptoms typical of cachexia. Conversely, 5 buds of cachexia-infected Orlando tangelo were propagated on seedlings of Palestine sweet lime (C. aurantifolia) grown from seed from the California Citrus Experiment Station at Riverside. One of these buds died, but all sweet lime stocks developed typical xyloporosis bark symptoms within a 4-year period.

Transmission of cachexia through seed: Fifty Orlando tangelo trees from seed of cachexia-infected parent trees and 50 trees from seed of cachexia-free Orlando parent trees developed no symptoms within a 4-year period. Of 135 Orlando tangelo seedlings from a commercial source, some unbudded and others budded with cachexia-free buds, none developed cachexia symptoms within a period of 4 to 6 years. However, in one lot of 121 unbudded Orlando tangelo seedlings from the same commercial source, 3 seedlings developed mild symptoms suggestive of cachexia infection at the age of 6 years. Whether the causal agent of cachexia was transmitted through the seed or insect or whether root graft transmission occurred is unknown.

As part of another experiment, 30 one-year-old Rough lemon seedlings were obtained from a commercial nursery and set out at the station but not budded. Ten of these trees died, but at the end of 4 years 8 of the remaining 20 trees showed brown-gum-impregnated spots in the phloem of the lower trunk suggestive of cachexia.

Transmission of xyloporosis through seed: Commercial Florida sweet lime seedlings approximately one year old were treated in the nursery row as follows: 10 were budded with cachexia-free Orlando tangelo buds, 10 were inoculated with an actinomycete isolated from citrus roots as part of another experiment not related to cachexia, and 10 were treated as checks on the actinomycete inoculation (i.e., surface sterilized, cut with a sterile knife, wrapped with rubber grafting tape, and coated with a grafting preparation consisting of water-emulsified asphalt). Two months later the seedlings were set out in an experimental planting at the Orlando station. Within 4 years mild symptoms of xyloporosis, wood pitting, and slight discoloration of the phloem, developed in the region of the trunk above the root crown in the following numbers of the sweet lime trees: 5 of the trees budded with cachexia-free Orlando tangelo buds, 7 of the trees inoculated with the actinomycete culture, and 8 of the check trees that were cut in a sterile manner but not inoculated. Thus of 30 sweet lime seedlings, 20 developed bark symptoms of xyloporosis within the 4-year period.

SUMMARY AND CONCLUSIONS

Cachexia symptoms have been consistently produced on Orlando tangelo seedlings through inoculation with buds from infected trees (2, 3). Buds from trees on xyloporosis-affected sweet lime rootstocks in Florida gave rise to typical cachexia symptoms when propagated on Orlando tangelo seedlings. In the reverse procedure typical xyloporosis symptoms were induced in Palestine sweet lime rootstocks, when they were budded with buds from cachexia-affected Orlando tangelo trees. From these results it appears that the difference between Orlando tangelo and sweet lime in symptom expression may be a matter of differences in host response.

Transmission of the causal agent of cachexia (probably a virus) through the seed of Orlando tangelo is apparently rare if it occurs at all. On the other hand, the causal agent of xyloporosis (probably the same virus) was apparently transmitted through 66 percent of 30 sweet lime seed. The xyloporosis symptoms noted in Israel (9) on unbudded sweet lime seedlings could be explained on the basis of the present evidence that xyloporosis is transmissible through the seed. Transmission of cachexia through the seed of Rough lemon is believed to be indicated but not fully established. These preliminary results need verification, and such work has been started. The possibility of seed transmission of xyloporosis is of such importance to the citrus budwood certification programs in Florida or elsewhere that the preliminary evidence is reported.

It is obvious that xyloporosis or cachexia cannot be controlled solely through propagating

buds free of the virus if seedlings used as rootstocks carry the causal agent of the disease. Also the assumption that citrus nucellar seedlings are a priori disease-free may be questioned in the light of the experiments reported.

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HORTICULTURAL CROPS RESEARCH BRANCH, AGRICULTURAL RESEARCH SERVICE, UNITED STATES DEPARTMENT OF AGRICULTURE, ORLANDO, FLORIDA

EFFECTS OF INOCULATION OF STRAWBERRY ROOTS WITH MEADOW NEMATODES, PRATYLENCHUS PENETRANS

A. C. Goheen and J. B. Smith[1]

Summary

The meadow nematode, Pratylenchus penetrans, can enter strawberry roots directly and feed and reproduce itself therein, thus proving that it is a primary parasite of strawberry. Inoculations with large numbers of this nematode produced marked stunting of the plants. Plants set in soil infested with this nematode did not survive and grow so well as plants set in nematode-free soil. The roots of plants from nematode-infested soil were badly rotted and showed typical black root rot symptoms, whereas those from nematode-free soil were almost free of rot.

Steiner (14) first reported meadow nematodes from the roots of strawberries from Florida and Massachusetts 25 years ago. Chaplin (3) found that they were widely distributed in strawberry plants in the United States; 20 of 22 strawberry root samples submitted to him from as many States were infected. Similarly, Goheen and Bailey (5) found that they were present in 20 of 24 root samples from strawberry fields in 8 counties in Massachusetts.

In 1934 Hildebrand (8) suggested that nematodes might be the cause of strawberry root rot when he found them frequently and consistently associated with diseased strawberry roots in the Niagara Peninsula of Ontario. Later Hildebrand and West (9) identified the nematodes associated with strawberry root rot in that area as Pratylenchus pratensis. Hastings (7) in 1935 reported that meadow nematodes cause a root decline of narcissus and strawberry roots in British Columbia. Bosher (2) later identified P. pratensis from diseased strawberry roots in Fraser Valley of British Columbia and P. penetrans from those on Vancouver Island. Klinkenberg (10) also found meadow nematodes associated with black-root rot of strawberry in the Netherlands and Allen and Raski (1) found them associated with a strawberry root rot in California. None of these investigators established meadow nematodes as the causal agents for strawberry black-root rot, but all demonstrated the frequent occurrence of the nematodes on plants with black-root rot symptoms.

Inoculation experiments with pure cultures would be necessary to determine whether meadow nematodes cause black-root rot of strawberries. Pure cultures of these organisms are difficult to obtain. Klinkenberg (11, 12) made inoculations with contaminated nematodes extracted from the soil. She introduced them into a compost in which strawberry seedlings were growing and compared these seedlings with others growing in nematode-free compost. Black-root rot developed where nematodes were present but not where they were absent. From this finding, Klinkenberg concluded that meadow nematodes must be present before the associated saprophytic or weakly parasitic soil fungi are able to attack strawberry roots. Evidence proving that meadow nematodes are primary strawberry parasites and showing that they can severely damage strawberry roots has been obtained at Beltsville, Maryland.

Parasitism of strawberry roots by meadow nematodes

Parasitism by meadow nematodes, Pratylenchus penetrans, was proved in the following manner. Nematode-free Blakemore strawberry plants were set in pots of sterilized soil to which the chopped roots of strawberry plants infected with meadow nematodes were added. At the end of 2 months the plants were taken from the pots and washed free of all soil. Samples of feeder roots were stained by the method described by McBeth et al. (13). Meadow nematodes and eggs were found in these roots (Fig. 1), indicating that the nematode can enter, feed upon, and reproduce in strawberry roots.

Effect of meadow nematodes on inoculated strawberry plants

The effect of inoculation with a large population of meadow nematodes on the growth of strawberry plants also was studied.

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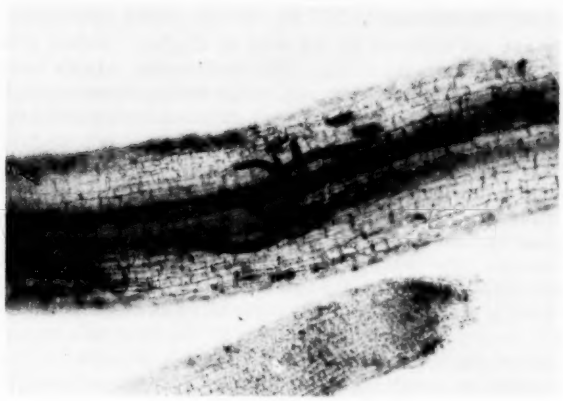

FIGURE 1. Meadow nematodes with eggs in a rootlet of a Blakemore strawberry plant 2 months after inoculation.

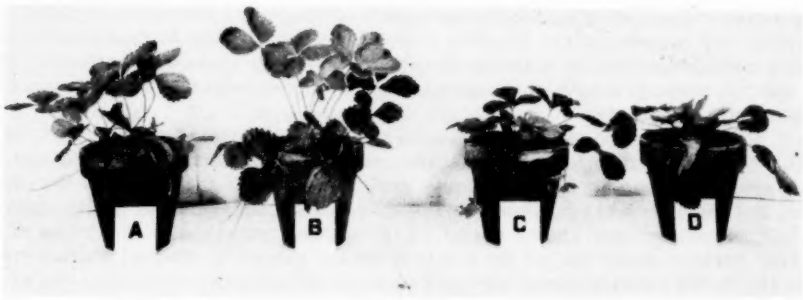

FIGURE 2. Nematode-free and meadow-nematode-infected Robinson strawberry plants after 7 weeks in the greenhouse. All plants were set the same date from stocks held in storage at 32° F. Plant A, from supposedly nematode-free screenhouse stock; B, from the same stock hot-water-treated at 127° for 2 minutes prior to setting; C, from black-root-rot-affected stock from Massachusetts with inoculum increased to 15,000 meadow nematodes by the addition of roots of similar affected plants; D, from hot-water-treated screenhouse stock similar to B but inoculated with 15,000 meadow nematodes from the roots of plants similar to those in C.

Robinson strawberry plants from methyl-bromide-fumigated soil in a screenhouse were dug during the winter and held in storage at 32° F. These plants were assumed to be relatively nematode-free, but they were not checked at the time of digging. Other Robinson strawberry plants were obtained from a commercial field in Massachusetts, where some of the plants were known to be seriously affected with black-root rot. The root system of each of these plants was found to be heavily infected, averaging approximately 3,000 meadow nematodes per plant.

Four 10-plant treatments were set up with 1 plant per 6-inch pot containing steam-sterilized soil. The first set consisted of nematode-free Robinson plants from the screenhouse; the second of nematode-free plants from the screenhouse that had been immersed in water at 127° F for 2 minutes before planting to kill nematodes (6); the third set of plants that had received the same handling as the second set but with excised roots of 5 meadow-nematode-infected plants from Massachusetts in each pot; and the fourth set of naturally-infected plants in pots to which had been added the excised roots of 4 additional nematode-infected plants. Thus, approximately 15,000 meadow nematodes were present in each pot in the third and fourth sets. Each pot containing a plant was set in a second 6-inch pot so that the bottom of the first was separated from the sand on the greenhouse bench by an air space of approximately 1 1/2 inches. The pots in each set were separated on the greenhouse bench from one another by approximately 18 inches to prevent contamination.

At the end of 7 weeks considerable differences in growth of the plants in the different sets were apparent (Fig. 2). The uninoculated screenhouse plants, both the non-hot-water-treated and the hot-water-treated ones, had made better growth than the inoculated plants. The hot-water-treated screenhouse plants in pots with infected roots, and the naturally infected plants from Massachusetts inoculated with meadow nematodes had made uniformly poor growth.

The most noticeable symptom on the meadow-nematode-infected plants after 7 weeks was a general stunting. The infected plants had approximately the same number of leaves as the non-infected ones, but the leaflets were smaller and the total leaf area of an infected plant was only 1/2 to 2/3 that of a non-infected plant. On an infected plant the older leaves were dark green, but the younger ones were chlorotic and somewhat rugose. The average petiole length for infected plants was approximately 2 inches compared with 7 inches for noninfected ones. The average number of runners for infected and noninfected plants was approximately the same (4 per plant), but the average length of runners for infected plants was 3.5 inches compared with 14 inches for the noninfected.

The growth differences apparent after 7 weeks gradually decreased as the plants became pot-bound. At the end of 10 months the plants were removed from the pots and washed free of soil. The root systems of the noninfected plants were much longer than those of the nematode-infected plants, but they were not measured. The roots of the screenhouse and the hot-water-treated uninoculated screenhouse plants were free of meadow nematodes. The roots of the inoculated hot-water-treated plants and of the plants from the naturally infected stock were infected with approximately 6,000 meadow nematodes per plant, indicating that the population of meadow nematodes in the roots of the plants had evidently reached an equilibrium at 6,000 per root system.

Growth of strawberry plants in soil infested with meadow nematodes

The effect of meadow-nematode-infested soil on the growth of nematode-free plants also was investigated. The nematode-infested soil from the inoculated hot-water-treated screenhouse plants in the previous experiment was collected, mixed thoroughly, and placed in 13 5-inch pots. Likewise, the nematode-free soil from the hot-water-treated screenhouse plants was collected, mixed, and placed in a second set of 13 5-inch pots. Robinson strawberry plants were removed from cold storage and immersed in water at 127° F for 2 minutes to kill nematodes, and 1 plant was set in each 5-inch pot. The pots were then placed in empty 5-inch pots to protect the bottom of the first pots from direct contact with the greenhouse bench and arranged 12 inches apart on the bench.

Differences in survival, growth, and root development were found. Of the 13 plants in nematode-free soil 12 survived in contrast to only 7 in infested soil. At the end of 4 months the average leaf area of the plants in nematode-free soil was 25.4 square inches and that of the plants in infested soil was 19.3 square inches. At the end of 7 months, when the plants were removed from the pots, the weight of the roots of the plants in nematode-free soil averaged 38.5 grams and that of the roots in infested soil 24.2 grams. No nematodes were found in the roots from nematode-free soil, but 250 nematodes per gram were found in the roots from infested soil. Little necrosis was found in the roots from nematode-free soil, but the roots from

infested soil had 60 to 80 percent black root-rot.

Discussion

While the findings presented here do not prove conclusively that Pratylenchus penetrans is the primary cause of strawberry black-root rot, the fact that this nematode can enter roots directly and reproduce proves that it is a primary parasite of strawberry plants. Furthermore, considerable stunting with massive inoculations with this nematode indicates that it is capable of producing injury. Also, the findings by Allen and Raski (1) that meadow nematode control by preplanting fumigation improved root development and growth of the above-ground part of strawberry plants and increased yields as found by Goheen (4) are additional evidence that meadow nematodes can cause serious damage to strawberry roots.

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THE RELATIONSHIP OF THE STUNT NEMATODE TO GRANVILLE WILT RESISTANCE IN TOBACCO

G. B. Lucas and L. R. Krusberg

Abstract

Greenhouse experiments indicated that Tylenchorhynchus claytoni did not increase severity of bacterial wilt (Xanthomonas solanacearum) in wilt-resistant tobacco plants grown in soil infested with both pathogens.

Greenhouse tests have demonstrated that root-knot nematodes (Meloidogyne sp.) greatly increase the severity of Granville wilt, caused by Xanthomonas solanacearum (E. F. Sm.,) Dowson in a flue-cured tobacco variety resistant to the latter disease (5). Holdeman (2) showed that another nematode that attacks tobacco, the tessellate stylet or stunt nematode, Tylenchorhynchus claytoni Steiner, increases the incidence of Fusarium wilt of tobacco (2). On the other hand, Martin et al. (6) found that Tylenchorhynchus sp. did not significantly increase the incidence of Fusarium wilt in wilt-resistant cotton. T. claytoni is widespread in the flue-cured tobacco growing areas of the Southeastern United States where it causes considerable damage to the crop. It is of interest to know if this nematode also increases the severity of Granville wilt in resistant varieties of tobacco. Therefore, the possible interaction of these two pathogens was investigated in greenhouse experiments.

Materials and Methods

Seedlings of Dixie Bright 101, a tobacco variety moderately resistant to Granville wilt, were grown to transplant size, repotted into 6-inch pots and divided into groups of 20 uniformly sized plants as described by Lucas et al. (5). Each group received one of the following 6 treatments: 1) 50 ml of a suspension (containing approximately 16×10^7 bacteria per ml) of X. solanacearum, poured around the roots of each plant at the time of transplanting; 2) approximately 1 pint of soil, containing larvae and adults of T. claytoni added to the disease-free soil in each pot; 3) same as in 1) except that the bacteria were added 3 days after transplanting; 4) nematodes as in 2) plus bacteria as in 1); 5) nematodes as in 2) plus bacteria as in 3); and 6) controls, receiving neither pathogen. It was not feasible to include all treatments in each of the 7 tests conducted. However, each treatment was included in at least 2 experiments.

The stunt-nematode inoculum was obtained by growing tobacco plants in the greenhouse for 6 to 8 weeks in 6-inch pots in methyl bromide-fumigated soil which had been artificially infested with T. claytoni. Nematodes were separated from the soil using the Baermann funnel technique and counted. The numbers of nematodes used per pot were approximately 1600, 2800, 1000, 600, 400, 400, and 600 in tests 1 to 7, respectively. The bacterial inoculum was prepared from 3-day-old potato-dextrose agar cultures. The virulent colony type of X. solanacearum, which had been checked for pathogenicity by the tetrazolium agar technique (4), was used.

In test 1, 2, 3, and 7 an attempt was made to minimize root injury at repotting by keeping intact the entire ball of soil containing the roots. In the fourth test, to insure close contact of the roots with the nematode-infested soil the ball of earth was washed from each plant just prior to transplanting. In the fifth and sixth experiments about two-thirds of the ball of soil was removed from each plant in order to injure the roots and bring the nematode-infested soil in contact with newly formed roots. Greenhouse temperatures ranged from 21 to 27° C at night and 27 to 38° C in the daytime. Height measurements and wilt readings were taken at weekly intervals. Disease indices were prepared following the method used by Winstead and Kelman (7).

Experimental Results

The severity of Granville wilt was not increased significantly in the presence of T. claytoni in any of the tests (Table 1). Plants inoculated only with bacteria usually exhibited wilt symptoms equal to or greater than those grown in the presence of both pathogens. Plants in nematode-infested soil inoculated with bacteria grew as rapidly as plants in nematode-free soil inoculated with bacteria. However, plants in nematode-infested soil grew at a significantly slower rate than non-inoculated controls.

Table 1. Relative severity of Granville wilt in Dixie Bright 101 tobacco plants inoculated with Xanthomonas solanacearum alone and in combination with Tylenchorhynchus claytoni.

Type of inoculation	Disease index[a] 3 weeks after transplanting						
	Test number						
	1	2	3	4	5	6	7
Bacteria added at transplanting	85	24	86	45	100	56	72
Bacteria added 3 days after transplanting	--	--	--	27	52	29	49
Nemas and bacteria added at transplanting	86	30	53	--	--	5	92
Nemas added at transplanting, bacteria added 3 days after transplanting	38	--	--	21	35	34	45

[a] 100 = all plants dead.

Discussion and Conclusions

It has been shown that the root-knot nematode facilitates infection by the Granville-wilt bacterium by wounding the roots and providing multiple infection courts for the bacteria (5). The wounds made by root-knot nematodes as they invade the roots typically extend into the stele, thus providing direct access to the vascular tissue. On the other hand, Tylenchorhynchus claytoni is an ectoparasitic nematode; larvae or adults are seldom found within the root tissues. Moreover, it is doubtful if the feeding punctures made by the nematodes normally penetrate to the xylem tissues. This lack of access to the vascular tissue may explain in part why T. claytoni does not increase the severity of Granville wilt to the same marked extent as the root-knot nematode.

In three of the tests, the symptoms of Granville wilt were less severe on plants growing in nematode-infested soil than in non-infested soil. It may be postulated that in these experiments the nematode-infested soil contained some substance deleterious to the bacteria that reduced their number. This explanation appears to be inadequate because in the other experiments wilt symptoms were as severe, or even more so, in the presence of both pathogens as in soil inoculated with bacteria only. Another explanation for the lower wilt index in certain tests may lie in a consideration of the root systems of tobacco plants grown in soil infested with T. claytoni. Such plants make poor growth, have retarded root systems with shrivelled, sparsely developed roots that lack turgidity and do not elongate normally (1). On the other hand, plants in nematode-free soil have vigorous, actively-growing root systems. It has been shown that the optimum development of wilt occurs in vigorous, actively-growing plants (3). It may be that roots attacked by T. claytoni are weakened to such an extent that they provide a less suitable environment for the bacteria and pathogenesis is retarded.

Summary

The relationship between infection by Tylenchorhynchus claytoni and severity of Granville wilt in a moderately wilt-resistant tobacco variety, Dixie Bright 101, was investigated in greenhouse experiments. Tobacco plants were grown in soil to which Xanthomonas solanacearum and T. claytoni were added alone and in combination. Plants inoculated only with bacteria exhibited wilt symptoms equal to or greater than those grown in the presence of both pathogens. The possible relation between the shallow feeding punctures made by the nematodes, the sparsely developed, shrivelled root system and the lack of increase in severity of Granville wilt is discussed.

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REDUCTION IN YIELD OF COTTON CAUSED BY DISEASES IN 1955

Compiled by the Cotton Disease Council, Committee on Disease Losses, Philip J. Leyendecker, Chairman; A. L. Smith, W. E. Cooper, Leonard Lett.

The accompanying tabulated summary of the 1955 Cotton Disease Loss Estimate (Table 1) is the fourth summary report submitted by the Committee on cotton disease losses. The Committee feels that the summary has helped to focus attention on the importance of diseases in the production of cotton in the United States. A loss of one and one-half million bales is certainly worthy of continued and increased State and Federal funds for phytopathological Research.

The summary has been compiled as in previous years, from 45 State estimates. The accuracy of the estimates is extremely high because most of the same cooperators have contributed for the last 4 years and as a consequence their methods and techniques are becoming uniform. The Committee feels that considerable credence can be placed in the report as it is now being prepared.

The total loss and average yearly loss in bales caused by the major cotton diseases for the whole period 1952 through 1955, during which these estimates have been compiled, are given in Table 2.

The Committee wishes to acknowledge the help of all who contributed to the report, and further solicit their cooperation in making the cotton disease loss report a continued success.

The list of cooperators follows:

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Table 1. ESTIMATED PERCENTAGE REDUCTION IN YIELD OF COTTON CAUSED BY DISEASES IN 1955.

Disease	Calif.	Ariz.	N.Mex.	Tex.	Okla.	Mo.	Ark.	La.	Miss.	Ala.	Ga.	S.C.	N.C.	Tenn.	Bales lost	Percent loss
1. FUSARIUM WILT																
Fusarium vasinfectum	0 0	0	0	0.01	0.01	2.0	2.4	3.0	2.0	0.3	1.5	3.05	1.5	2.2	173, 883	1.29
2. VERTICILLIUM WILT																
Verticillium albo-atrum	2.1	3.1	7.5	0.6	0.1	0	1.0	0.1	1.75	Tr	0	0	0.4	1.7	189, 168	1.38
3. BACTERIAL BLIGHT																
Xanthomonas malvacearum	Tr	.41	0.1	2.2	2.0	0.5	1.25	0.5	1.75	1.5	1.5	1.05	2.0	0.2	222, 611	1.08
4. ROOT ROT																
Phymatotrichum omnivorum	Tr	2.18	0.1	3.3	0.3	0	Tr	Tr	0	0	0	0	0	0	164, 236	0.42
5. ANTHRACNOSE BOLL ROT																
Glomerella gossypii	0	0	0	0.9	Tr	0.1	0.1	0.5	1.0	1.0	0.5	0.25	0.5	0.6	89, 833	0.4
6. SEEDLING DISEASES																
Rhizoctonia, etc.	4.0	2.66	95	2.0	3.0	10.0	2.5	3.5	0.75	0.2	3.0	1.25	3.0	0.5	363, 533	2.67
7. ASCOCHYTA BLIGHT																
Ascochyta gossypii	0	0	0	0.06	0	0.5	0	0	Tr	0	0.5	0.05	0.1	0.4	12, 246	.11
8. BOLL ROTS																
Rhizopus, etc.	1.8	1.9	0.05	0.3	5.0	1.0	3.25	2.0	1.75	2.0	0.75	7.0	10.0	1.6	322, 082	2.75
9. ROOT KNOT																
Meloidogyne sp.	2.1	2.02	0.45	0.01	0.5	1.0	1.3	Tr	0.5	2.0	1.75	3.0	3.5	0.8	164, 795	1.35
10. OTHERS	Tr[a]	0.5[b]	0	0	0	0	0	0	0	0	0	0	0	0	3, 947	
TOTAL PERCENT LOSS	10.0	12.77	9.15	9.38	11.0	15.1	12.7	9.6	9.5	7.0	9. 5	15.65	21.0	8.0		11.45
TOTAL BALES LOST	137, 500	100, 805	26, 466	412, 838	54, 890	70, 389	236, 163	61, 551	208, 050	78, 270	73, 338	103, 165	90, 205	52, 704	1, 706, 334	
YIELD IN BALES 1955[c]	1, 250, 000	700, 000	265, 000	4, 025, 000	450, 000	405, 000	1, 650, 000	585, 000	2, 000, 000	1, 045, 000	705, 000	570, 000	355, 000	610, 000	14, 663, 000	

[a] Crumple leaf virus.
[b] Rust (Puccinia stakmanii Presley).
[c] Dec. 1, 1955, BAE Estimate.

Table 2. Reduction in cotton yield caused by parasitic diseases in the United States, 1952 to 1955, inclusive.

Disease	Bales lost	
	Total	Average
1. Seedling diseases (Rhizoctonia, etc.)	1,756,319	439,080
2. Bacterial blight (Xanthomonas malvacearum)	851,508	212,877
3. Root knot (Meloidogyne sp.)	851,089	212,772
4. Verticillium wilt (Verticillium albo-atrum)	809,650	202,413
5. Fusarium wilt (Fusarium vasinfectum)	785,164	196,291
6. Boll rots (Rhizopus, etc.)	739,904	184,976
7. Root rot (Phymatotrichum omnivorum)	566,138	141,535
Total	6,359,772	1,589,943

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COTTON DISEASE COUNCIL COMITTEE ON DISEASE LOSSES

STUART PECAN FOUND TO BE SUSCEPTIBLE TO SCAB IN MISSISSIPPI

John R. Cole and A. C. Gossard[1]

Pecan scab, caused by Cladosporium effusum, has long been recognized as one of the factors limiting pecan production. It certainly is the most important disease affecting pecans. Fortunately, some varieties are more resistant than are others. The Stuart, which is one of the most widely planted varieties, has until now shown the most resistance to this disease. In some instances both research workers and growers have reported finding "traces" of scab on the nuts of Stuart variety under southeastern conditions, but the damage was of minor importance.

In recent years, increasing numbers of reports have been received about the appearance of scab on the Stuart variety in southeastern Mississippi, especially near Laurel and Lumberton. These reports prompted an investigation as to whether the trouble was caused by scab and whether the variety affected was Stuart.

In October 1955 the writers made a thorough investigation and found scab affecting the Stuart variety. Spores were present on the scab lesions, but the disease was confined to the nuts. The damage was great enough to cause economic loss at both Laurel and Lumberton.

Why the Stuart variety remained resistant to scab for over half a century, even under ideal conditions for scab infection, is a mystery to the writers. The Stuart variety has been the one most widely and extensively planted. Furthermore, the disease has not been observed by the writers on the Stuart variety in other localities where it is interplanted with such highly susceptible varieties as Delmas, Pabst, Alley, and Schley.

Demaree and Cole[2] reported in 1929 that the scab fungus had the ability to adapt itself to the Stuart as well as to other varieties. They further stated that "a variety known to be susceptible is often free from the disease when grown in the same locality with other varieties that are severely attacked. Trees of a susceptible variety may also be growing in the same orchard in contiguous rows, or even with their branches interlocking those of scab-diseased trees of another variety, and not be affected with the disease. Varieties are sometimes very susceptible in one locality and apparently immune in others."

Since a strain of the pecan scab fungus usually starts on the nuts of the tree in the region of its origin, and since the Stuart variety originated on the Gulf Coast of Mississippi, it is quite possible that this strain will spread rapidly both eastward and westward. However, its spread can be delayed where growers control the disease by spraying and destroying the old pecan shucks. Sanitation might even delay the spread of the fungus to the leaves and shoots of the Stuart variety. In addition, care should be exercised not to transport nursery stock or scionwood from localities where scab is known to be present on the Stuart to areas where the disease has not been found on it.

HORTICULTURAL CROPS RESEARCH BRANCH, AGRICULTURAL RESEARCH SERVICE,
U. S. DEPARTMENT OF AGRICULTURE

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[1] Pathologist and Horticulturist, respectively, Horticultural Crops Research Branch, Agricultural Research Service, U. S. Department of Agriculture.

[2] J. B. Demaree and J. R. Cole. 1929. Behavior of Cladosporium effusum (Wint.) Demaree on some varieties of pecan. Jour. Agr. Res. 38: 363.

HYPOXYLON CANKER OF ASPEN IN COLORADO

Ross W. Davidson and Thomas E. Hinds[1]

Hypoxylon canker of aspen (Populus tremuloides Michx.) caused by H. pruinatum (Kl.) Cke., is considered one of the most important tree diseases in the eastern sections of North America.(2). It has not been reported as definitely present in the central Rocky Mountain area although other aspen cankers (4) are common in this area. Boyce (3) has reported that Hypoxylon canker probably occurs in Colorado. He refers to a paper by Hartley and Hahn (5) but these authors merely report cankers on aspen without proof as to whether Hypoxylon is involved[2, 3].

Although considerable study on Hypoxylon canker has been made in Canada (2) and special disease surveys have been conducted for it in Alberta (1), the disease has not been reported from the Rocky Mountains there. It was collected in six locations in the interior of British Columbia in 1953 (6).

In June 1955, during decay studies in aspen on the Routt National Forest, north of Hayden, Colorado, Hypoxylon cankers were observed for the first time by the writers (Fig. 1, A & B). The first canker seen was on a tree 16 inches d. b. h., which had been completely girdled within the past year. This canker contained perithecia in the central part of the cankered tissue (Fig. 1, C) and old conidial fruiting under blister-like patches of the outer peridem near the canker margin (Fig. 1, D). Several days later additional trees with cankers were observed in the same general area.

There has been no opportunity for a general survey for Hypoxylon since this original discovery. However, a number of similar Hypoxylon cankers were observed about 20 miles north of Durango in southwestern Colorado. The Hayden location is in northwestern Colorado and both are on the Western Slope of the Rockies.

It would seem that this disease is probably present elsewhere in the region. It is strange that during the 1954 decay study in aspen no Hypoxylon was seen, in spite of the fact that attention was given to several other cankers of aspen in the course of that work.

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6. Molnar, A. C. 1954. Province of British Columbia Forest Disease Survey. In Annual Report of the Forest Insect and Disease Survey, 1953. Canada, Forest Biol. Div., pp. 150-158.

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[1] Forest Pathologist and Forestry Aid (Research), respectively, Rocky Mountain Forest and Range Experiment Station, Forest Service, U. S. Department of Agriculture, with central headquarters at Fort Collins, Colorado, in cooperation with Colorado A & M College.

[2] Several specimens of closely-related Hypoxylon species have been collected on other hosts such as Salix and Alnus in Colorado, but they were not reported as causing cankers.

[3] The writers are indebted to Dr. Paul Lentz, Mycologist, Plant Disease Epidemics and Identification Section, Agricultural Research Service, Beltsville, Maryland, for examination of Hypoxylon herbarium specimens.

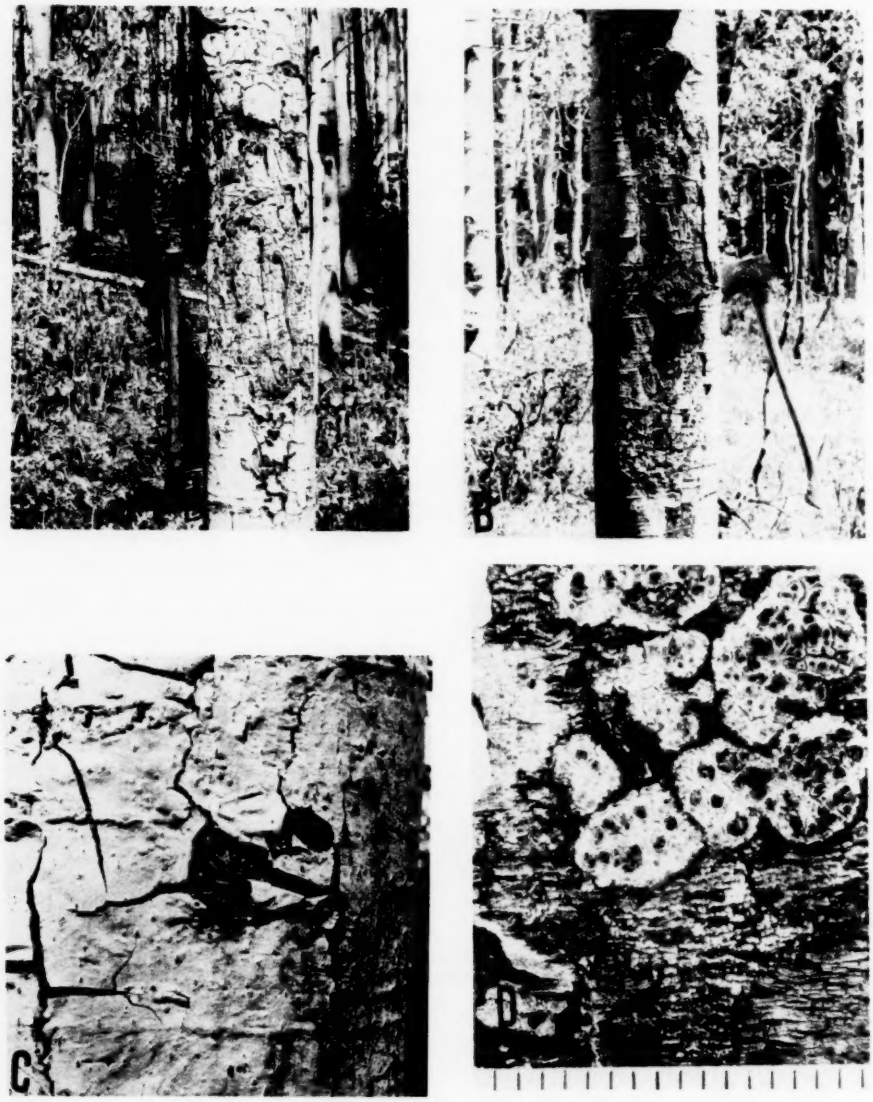

FIGURE 1. A and B -- Hypoxylon cankers on main stems of aspen, Hayden, Colorado; C -- Old conidial area near margin of a canker; D -- Perithecia of the fungus causing the cankers, enlarged.

ROCKY MOUNTAIN FOREST AND RANGE EXPERIMENT STATION, FOREST INSECT AND DISEASE LABORATORY, SOUTH HALL, COLORADO A AND M COLLEGE, FORT COLLINS, COLORADO

1955 PLANT DISEASE SUMMARY FOR NEW MEXICO

Philip J. Leyendecker[1] and Roy M. Nakayama[1]

1. Scab (Streptomyces scabies (Thaxt.) Waksman & Henrici) on radish was found for the first time in New Mexico this season. The disease caused a complete loss of a 10-acre field planted to Scarlet Globe. Infection was so severe that it was not economically feasible to harvest and sort out the disease-free radishes. This field had not previously grown a root crop. Scab lesions were extremely severe, and sometimes they extended into the cortex of the radish hypocotyl.

2. Verticillium wilt (Verticillium albo-atrum Reinke & Berth.) was very severe because of an unusually cool growing season and caused considerable damage on the following crops.

a. Cotton (Upland) -- Wilt caused a 7.5 percent yield reduction, or 21,695 bales. Losses in some fields in the Mesilla Valley ran as high as 35 percent. An increase in severity of wilt was also very evident in the Pecos Valley of eastern New Mexico. Many fields with little or no Verticillium wilt history suffered considerable losses. The increase in wilt was brought about in part by the lack of rotation with small grains and soil-building crops.

b. Okra -- Plantings of Clemson Spineless in the Mesilla Valley were severely damaged by wilt. Growers reported a 50 to 75 percent loss in production. Because the disease appeared unusually early, severe stunting and extreme defoliation resulted. Infection continued to increase during the season until by frost time 100 percent of the plants were diseased. Little if any fruit was harvested from plants that showed disease symptoms before mid-July. The severely-infected fields had been rotated with other vegetable crops. Okra had not appeared in the rotation sequences for at least 5 years.

c. Tomato -- Verticillium wilt was responsible for severe damage in a 5-acre field of tomatoes in the Mesilla Valley. Prior to this occurrence, Verticillium had not been isolated from any commercial planting of tomatoes in New Mexico. Typical stem discoloration and leaf symptoms were present. Ninety to 95 percent infection occurred by late season, resulting in a 40 percent reduction in yield.

3. Big bud (Virus, Galla australiensis Holmes) occurred in commercial plantings of tomatoes and bell and chile peppers. The virus has been found throughout the State and is increasing in severity. From 1 to 2 percent infection is common in most tomato fields. If fruit is set on diseased plants, it is irregular in shape and colors very unevenly.

In one large field of chile peppers, approximately 2 percent of the plants were infected. Big bud symptoms on chile pepper are slightly different from those on tomatoes. Infected pepper plants are light yellow, and the leaves are rigid and tend to roll upward from the margins to the midrib, giving the plant a pronounced yellow, bushy appearance. On tomatoes, early infection seems to affect only the inflorescence, producing proliferation and abnormal floral growth. The diseased foliage is bright green, which makes it difficult to detect early-season infection. Only upon very close observation can the ballooned flowers and malformed inflorescences be found on diseased plants. In late season, however, the malformed inflorescences and leaves turn purple, and the virus-infected tomato plants can be detected very easily.

4. Curly top (Ruga verrucosans Carsner & Bennet), which occurs every year throughout the State, was not so severe as in previous years. The virus caused some damage to tomatoes and peppers and was recorded on snap beans. Some growers are reporting satisfactory control of curly top of tomatoes by heavy field-seeding, followed by late thinning. The shading brought about by thick planting seemed to discourage early feeding by the vector, the sugar beet leafhopper.

5. Mosaic (Marmor cucumeris Holmes) on chile pepper was very severe in northern New Mexico. A combination of the cucumber virus and what appeared to be a calico virus was present in some fields. The calico virus occurred singly and also in combination with the cucumber mosaic virus. An unusually cool season brought about stunting and severe leaf malformation. Numerous home garden plots were so hard hit that production was reduced 90 percent. Mosaic was very severe where the home plantings or fields were surrounded by weeds and native flora.

6. Virus (unknown). A virus disease, observed for the first time on chile peppers in New Mexico, appeared to be spotted wilt (Lethum australiense Holmes). Typical wilt symptoms oc-

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[1] Department of Agricultural Services, New Mexico College of Agricultural and Mechanic Arts, State College. Dr. C. H. Hsi of the Plains Substation furnished information concerning diseases that occurred in eastern New Mexico.

curred on the stems and leaves. These included dying back of stem tips, one-sided necrotic spotting of leaves, irregular brown patches on the stem, and scattered browning of the pith. Spotted wilt symptoms described on bell pepper fruit were not found on the chile pepper pods. Therefore, inoculation tests are under way to verify the identity of the virus. The disease is present in most areas of the State where chile peppers are grown. Most growers indicated that they had not observed the disease previously. The new, large-fruited, and heavy-producing pepper strains seemed to be more susceptible to the virus than did the native variety.

7. Purple blotch (Alternaria pori (Ell.) Cif.) of onion was very severe in a 5-acre field north of Albuquerque. Mature leaves were covered with necrotic, dark-purple areas, which were overgrown by the causal agent. Over half of the leaf surface was destroyed, resulting in small, premature bulbs. The disease was aggravated by a flash flood, which covered the field with 5 to 6 inches of water for 3 or 4 days.

8. Fusarium wilt (Fusarium oxysporum f. batatas (Wr.) Snyder & Hansen) of sweetpotatoes was observed in a 15-acre field of the Candy variety in the Mesilla Valley. Fifteen to 20 percent of the plants were diseased at harvest time, and 3 to 5 percent loss in yield occurred. In all probability, the infection came from infected roots which were used to produce the shoots for transplanting.

9. Fusarium wilt (Fusarium annuum Leonian ?) caused some damage in all chile plantings in New Mexico. An unusually cool season did not favor disease development, and the over-all damage caused by the disease was much reduced, compared to average yearly losses.

10. Southern blight (Sclerotium rolfsii Sacc.) of peanut was very prevalent in the Portales area. The disease accounted for a 15 percent loss in yield. In many fields, a 75 to 80 percent loss occurred. Infections were most severe in fields that had been cropped to peanuts for a number of years. Nut quality is expected to be one or two grades lower than in previous years.

11. Powdery mildew (Podosphaera leucotricha (Ell. & Ev.) Salm.) on apple appeared for the first time in several years in northern New Mexico. Terminal growth was seriously reduced in a number of large orchards. No control measures were taken, as the fungus appeared after the last codling moth spray was administered. Also, Podosphaera oxyacanthae (DC.) D By. was observed on sour cherry, and Microsphaera alni DC. ex Wint. on Forestiera neomexicana A. Gray.

12. Yellows (aster-yellows virus, Chlorogenus callistephi Holmes) of lettuce was found for the first time in New Mexico this year. The disease occurred in the Mesilla Valley on numerous fall plantings of strains of the Great Lakes variety. Stunting, yellowing, and exudation of latex droplets on the inner crinkled leaves were the outstanding symptoms. The virus occurred in most commercial fields, and the incidence ranged from a trace to 1 or 2 percent. Dusting with toxaphene and DDT did not have an appreciable effect upon control. It is believed that the viruliferous vector probably moved into the lettuce fields from native weed hosts.

13. Leaf spot (Alternaria spp.) on short staple cotton was quite severe early in the season in the Pecos Valley. In some fields, one-fourth or one-third of the inner leaves were shed. Spring rains which followed immediately after irrigations aggravated the disease. Usually, leaf spot occurs late in the season and is found most frequently on long staple cotton. The losses incurred by the disease could not be determined; however, it is believed that measurable losses did occur in fields where one-third of the leaves were lost. The leaf shedding was very similar to that caused by epiphytotics of bacterial blight of cotton.

14. Rust (Puccinia cynodontis LaCroix ex Desm.) on Bermuda-grass was observed in numerous lawns this past season. T-92, a new improved selection from Texas, appeared to be much more susceptible than the common Bermuda-grass now grown in southern New Mexico.

15. Rust (Puccinia poae-sudeticae (West.) Jørst.) of bluegrass appeared in Las Cruces in new lawns planted to the Merion variety. Spores were probably brought in on seed, since hardly any bluegrass is planted in southern New Mexico. Only urediospores were produced; therefore, winter temperatures may hold the disease in check.

16. Leaf rust (P. rubigo-vera var. tritici) on winter wheat caused considerable foliage damage in northern New Mexico. Infection ran as high as 30 percent in certain fields. Nine physiological races have been identified to date.

17. Root rot (Helminthosporium sativum Pam., King & Bakke, Rhizoctonia, etc.) of winter wheat occurred throughout the winter wheat section of the State. Stands were reduced by the crown rot phase of the disease, resulting in a considerable reduction in yield. A 15 to 20 percent loss in grain yields occurred.

18. Charcoal rot (Macrophomina phaseoli (Maub.) Ashby) of sorghums was prevalent in the northeastern part of New Mexico. The rot caused serious lodging, which resulted in reduced yields and increased difficulty of harvesting. Fields were observed that suffered a 50 percent

loss in yield. Rot was most severe in fields that had been continually cropped to sorghums.

19. Anthracnose (Colletotrichum spp.) of broom corn was found for the first time in New Mexico in the Clovis area. Yields were seriously reduced because of premature head ripening caused by the fungus. Anthracnose has probably been present in New Mexico, but remained undetected because climatic conditions had not favored its development for a number of years.

20. Damping off (Rhizoctonia solani Kuehn) of cotton was very serious because of an unusually cool, late spring. Sore shin or post emergence damping-off was extremely severe. Seed treatment protected the seed from rotting and usually increased emergence, but because of climatic conditions favoring sore shin stands could not be maintained. It was necessary for many farmers to replant two or three times to obtain satisfactory stands. Only partial stands were obtained in old alfalfa fields which were being planted to cotton for the first time. A loss of 1 percent, or 2,750 bales, was attributed to this disease. This estimate does not include cost of seed, replanting, etc.

NEW MEXICO COLLEGE OF AGRICULTURAL AND MECHANIC ARTS, STATE COLLEGE, NEW MEXICO

PLANT DISEASE LOSS ESTIMATES IN 1955 FOR TENNESSEE

J. O. Andes[1]

The 1955 season was much more favorable for crop production than for several past years due to more abundant rainfall. While disease incidence was severe in several cases attributable to environmental situations in the main no serious epidemics were experienced. Fruit was eliminated because of the late spring freeze. The use of resistant varieties in several instances, particularly tobacco, markedly reduced losses. Losses of relatively slight amounts due either to small value of the crop or very locally restricted are not included.

Table 1. Estimated loss from plant diseases of major importance in Tennessee, 1955.

CROP Disease	Occurrence	Percent loss		Remarks
		State-wide	Local	
(Fruits and vegetables)				
APPLE				
Scab, *Venturia inaequalis*				Crop practically total loss due to late freeze
Cedar rusts, *Gymnosporangium* spp.				
Fire blight, *Erwinia amylovora*				
PEAR				
Fire blight, *Erwinia amylovora*				Same as above
PEACHES				
Brown rot, *Monilinia fructicola*				Same as above
Scab, *Cladosporium carpophilum*				
STRAWBERRY				
Fruit rot, *Botrytis cinerea*	General	2	10	
Virus	General	3	5	
SWEETPOTATO				
Stem rot, *Fusarium oxysporum* f. *batatas*	General	1	5	
TOMATO				
Wilt, *Fusarium oxysporum* f. *lycopersici*	Local	2	10	
Nematodes	General	5	20	
Fruit rots, *Phytophthora parasitica*	Local	Trace	10	
Southern blight, *Sclerotium rolfsii*	Local	1	20	
(Field crops)				
ALFALFA				
Crown rot, *Sclerotinia trifoliorum*	General	2	25-30	
BARLEY				
Spot blotch, *Helminthosporium sativum*		1	3	
Scald, *Rhynchosporium secalis*		2	25	
Loose smut, *Ustilago nuda*		1	15	
Mildew, *Erysiphe graminis*		Trace	2-3	
CORN				
Ear, stalk, root rots, and seedling blight, *Diplodia* spp. and *Fusarium* spp.	General	1-2	10-15	
Leafspot, *Helminthosporium* spp.	General	Trace	4-5	

[1] Compiled with assistance of all pathologists and certain workers in crop specialty fields.

(Cont'd)

CROP Disease	Occurrence	Percent loss		Remarks
		State-wide	Local	
COTTON				
Fusarium wilt, Fusarium oxysporum f. vasinfectum	Local	2.2	5-8	
Verticillium wilt, Verticillium albo-atrum	Local	1.7	10	
Seedling diseases	General	0.5	10	
OATS				
Smuts, Ustilago spp.	General		Trace	
Crown rust, Puccinia coronata	General		Trace	
Mildew, powdery, Erysiphe graminis avenae	General	Trace	5	
SOYBEANS				
Damping-off, Rhizoctonia solani	General	Trace	10	
Leafspots, bacterial	General	Trace	Trace	
TOBACCO				
Wildfire and blackfire Pseudomonas tabaci Pseudomonas angulata	General	2-3	10-12	Resistant varieties reduced losses
Fusarium wilt, Fusarium oxysporum f. nicotianae	Local	Trace	5-6	Same as above
Frenching	Local	Trace	Trace	
Blue mold, Peronospora tabacina	Local	--	Trace	
Frog eye, Cercospora nicotianae	General	Trace	Trace	
Black shank, Phytophthora parasitica var. nicotianae	General	0.5	5-6	
Mosaic (virus)	Local	1	5	
Anthracnose, Colletotrichum spp.	Local	Trace	5	
Nematodes	General	Unknown	8-10	
WHEAT				
Loose smut, Ustilago tritici	General	Trace	2-3	
Leaf rust, Puccinia rubigo-vera tritici	General	Trace	3-4	
Stem rust, P. graminis tritici	Local	--	Trace	
Scab, Gibberella and Fusarium spp.	General	Trace	2	
Glume blotch, Septoria nodorum	General	Trace	Trace	

A CORRECTION

In the article by L. H. Person et al. in the December issue, on page 887, fifth paragraph, the next to last sentence should obviously read "In addition many chytrid zoospores were swimming in the water", instead of oospores as printed.

ANNOUNCEMENT

POTOMAC DIVISION MEETINGS SET FOR MARCH 1 AND 2, 1956

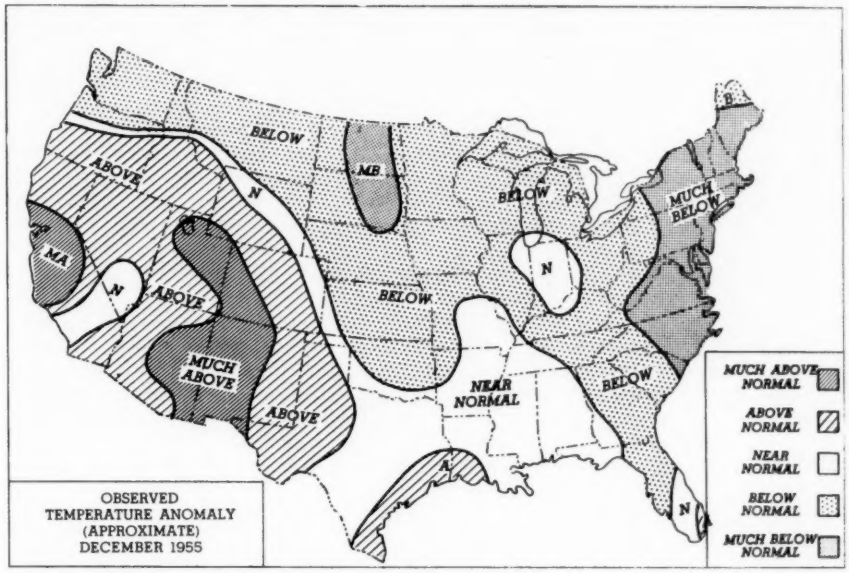
The two-day meetings of the Potomac Division of the American Phytopathological Society set for March 1 and 2 at the Plant Industry Station, Beltsville, Maryland. Papers of general interest will be given in the morning and afternoon session March 1 and a Market Pathology Symposium will be held the morning of March 2. This symposium will be moderated by Dr. Harold T. Cook, Head of Quality Maintenance and Improvement Section of the Agricultural Marketing Service, and the speakers are: Dr. Cook, who will review the "History and Development of Market Pathology"; Mr. L. P. McColloch with the topic "Control of Market Diseases by Means Other Than Fungicides"; Dr. W. L. Smith speaks on "Control of Post-Harvest Diseases by Fungicides"; Dr. B. A. Friedman of the New York Pathology Laboratory will discuss "Market Diseases in a Large City Market"; and Mr. W. H. Redit will speak on the topic "Transportation Problem in Relation to Post-Harvest Market Diseases." There will be a demonstration of equipment used in transportation tests.

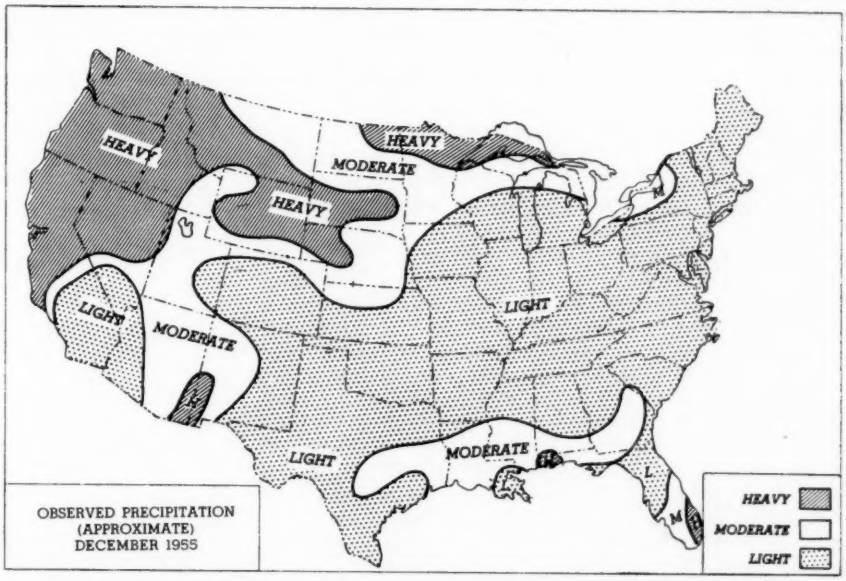
The annual banquet will be held the evening of March 1 in the St. Andrews Episcopal Church, College Park, Maryland. An interesting and entertaining program for that evening has been arranged under the direction of Dr. W. Q. Loegering.

Programs may be obtained from Dr. L. O. Weaver, Secretary and Treasurer, Department of Plant Pathology, University of Maryland, College Park, Maryland.

PROGRAM COMMITTEE:

R. E. Webb, Chairman
W. Q. Loegering
John G. Moseman
E. P. Imle





The terms used in the accompanying maps, which define the ranges of temperature and precipitation, are numerical class limits. These are based on a statistical analysis of past records through which is determined the normal frequency of occurrence of temperatures and precipitation at various times of the year for different locations. For temperature the classes above, below, and near normal are so defined that they each normally occur one-fourth of the time; much above and much below normal, one-eighth of the time Precipitation is depicted in terms of light, moderate, and heavy, each class normally occurring one-third of the time and thereby having equal probability of occurrence. These maps graphically represent only the general trends and give the country's weather picture at a glance. For quantitative studies, where monthly mean temperatures and actual precipitation records are needed for a given time and place, other publications of the Weather Bureau should be consulted. P. R. M.

MANUSCRIPTS FOR THE PLANT DISEASE REPORTER

(See also PDR 35: 121-122; 36: 214, 494)

(1) GENERAL: The Reporter page measures 9 inches long with the heading or 8 3/4 inches for the text part, by 6 inches wide. The copy is typed on a larger page, 11 1/4 inches of text or 12 inches overall in length by 8 inches in width, and reduced 25 percent in the photographic process of reproduction. Illustrations or tables larger in either dimension will take a correspondingly greater reduction. Only one size of type is available for text, footnotes, or tables.

(2) MANUSCRIPTS should be the original ribbon copy, not carbons, clearly typed and double-spaced throughout, including tables, footnotes, and bibliographies. (Note -- only one copy is needed.) Footnotes should be typed at the bottom of the page.

(3) ABSTRACTS are requested for all except very short articles. (PDR 38: 316).

(4) CAUSES OF DISEASES should be named. For bacteria, fungi, nematodes, etc., give the Latin name of the organism; for viruses either or both the accepted common name of the virus or a Latin name if you prefer it and there is one; for non-parasitic diseases state the causal factor if it is known. If the cause of a disease has not been determined say so. (PDR 36: 494).

(5) LITERATURE REFERENCES should be given in alphabetical order and numbered for citation in the text. We follow the AIBS suggestion of placing the year of publication after the author's name. Please check your titles carefully since we cannot do it for you. Be sure that text citations and bibliography agree; that foreign-language references are correct; that number or month is cited for periodicals that are not paged consecutively throughout the volume.

(6) NAMES OF FUNGICIDES should be given according to the suggestions that will be published in Phytopathology before long, and later repeated in the Reporter. In the meantime see PDR 35: 122.

(7) ILLUSTRATIONS should be sent to us unmounted. To prevent mistakes, write figure numbers on the back, and mark the top of each print when necessary. A sketch can show a preferred arrangement but please keep in mind page size, shape, and standard reduction (see above under General), and remember that figure titles and legends are part of the page. Lettering should be clear and large enough to be legible after reducing. Drawings, maps, and graphs can be photographs or originals, but should be finished and ready for reproduction, not just sketches.

(8) TABLES should be carefully thought out with particular attention to the Reporter's limitations in reproduction. Make titles and headings definite and self-explanatory. Designate footnotes in tables with superscript lower-case letters. Be sure that text discussion agrees with the data in the table. Do not abbreviate names of crop varieties.

(9) REPRINTS cannot be supplied since there is no way in which we can be reimbursed. However,

(10) The MULTILITH PLATES from which reprints can be made will be sent if requested at the time the article is submitted. The press size of these plates used for the Reporter is designated as small -- maximum image 9 1/2 by 13 inches, maximum paper size 9 3/4 by 14 inches -- for Model 1250. Most of the Experiment Stations have this type of multilith machine.

(11) We are the official correspondents in the United States of the PLANT PROTECTION BULLETIN published monthly by the United Nations Food and Agriculture Organization. We would appreciate it if plant pathologists would send us suitable material from time to time for inclusion in our monthly summary reports. Please mark it clearly so that we will know it is intended for the Bulletin. (See PDR 36: 492; 37: 637) -- P. R. M.